№ 0000111

99904

PHASE II REMEDIAL INVESTIGATION

of the . . .

Skinner Landfill Site
West Chester, Ohio

prepared for . . .

U.S. Environmental Protection Agency
Region V
Chicago, Illinois

EPA Contract No. 68-W8-0079
EPA Work Assignment No. 04-5L73
WW Engineering & Science Project No. 04003

May,1991

WW Engineering & Science

ARCS Program Management Office
U.S. EPA Contract No. 68-W8-0079
Transmittal Form

Date: May 15, 1991

Attention: Mr. Fred Bartman, Remedial Project Mgr.
WW Project No.: 04003

To: U.S. Environmental Protection Agency
230 South Dearborn Street, (5HS-11)
Chicago, IL 60604

U.S. EPA Assign. No.: 04-5L73
Project: Skinner Landfill
Project Location: West Chester, OH

We Are Sending You:

- [ ] Plans/Specs/Drawings
- [ ] Work Task Assignments/Change Orders
- [x] Reports Final RI
- [ ] Memorandums
- [ ] Contract Documents
- [ ]

Quantity	Description
3	Final Remedial Investigation Complete text, tables, and figures Complete appendices

These are Transmitted as Checked Below:

- [ ] Furnish as Submitted
- [ ] Furnish as Corrected
- [ ] Revise and Resubmit
- [ ] Submit Specified Item
- [ ]
- [ ] Rejected
- [ ] For Approval
- [ ] For Field Use
- [ ] For File
- [ ]
- [ ] For Your Information
- [ ] For Distribution
- [x] For your Use
- [ ] As Requested
- [ ]

Remarks:

CC: 04003, 32

By Joel Vanderkwaak, Geologist

WW Engineering & Science
ARCS Program Management Office
5555 Glenwood Hills Pkwy., SE, Grand Rapids, MI 49508; (616) 942-9600

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

(Table and Figures follow each corresponding section.)

SECTION 1

TABLES

FIGURES

SECTION 2

TABLES

FIGURES

LIST OF TABLES AND FIGURES (cont.)
(Table and Figures follow each corresponding section.)

SECTION 3

TABLES

FIGURES

SECTION 4

TABLES

FIGURES

LIST OF TABLES AND FIGURES (cont.)
(Table and Figures follow each corresponding section.)

SECTION 5

TABLES

FIGURES

1.0 INTRODUCTION

In December 1982, the United States Environmental Protection Agency (U.S. EPA) placed the Skinner Landfill site on the National Priority List (NPL) in group 14 with a ranking of 659. Phase I Remedial Investigation (RI) activities were initiated under REM II in 1984 by Roy F. Weston, Inc. (WESTON). WESTON's Phase I field activities resulted in the issuance of a Preliminary Phase I Remedial Investigation/Feasibility Study (RI/FS) report in December of 1988. Recommended Phase II RI activities were never fully implemented.

RI/FS work at the Skinner Landfill site has subsequently been transferred to WW Engineering & Science, Inc. (WWES) under an Alternative Remedial Contracting Strategy (ARCS) contract. The Phase II RI/FS of the Skinner Landfill site was authorized under U.S. EPA Work Assignment 04-5L763, executed on January 4, 1989, between the U.S. EPA and WWES.

This RI report describes the results of the Phase II field activities, the methods employed, and presents and analyzes the resulting data. The Phase II RI was conducted under the authority of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA).

1.1 PHASE II INVESTIGATION PURPOSE AND SCOPE

The primary purpose of the Phase II RI was to acquire additional data to more fully characterize the nature and extent of contamination, the migration or potential migration pathways of contaminants, and the hydrogeology of the site sufficiently to select appropriate remedial alternatives for evaluation during the subsequent Feasibility Study. This new information was also used to evaluate the potential risk to the environment and public health during risk assessment activities. The resulting comprehensive baseline risk assessment is being compiled as a separate document and will be submitted in December, 1990. All data gathered during the RI were obtained in accordance with the Quality Assurance Project Plan (QAPP) Addendum (September, 1989) and the Sampling Plan (September 1989).

The scope of work was designed to accomplish the following:

1. Further characterize the site and quantify the risk to human health and the environment. (Discussed in the Risk Assessment).

2. Better define the shallow bedrock hydrogeology. (Discussed in Section 4.0).

3. Estimate the extent and rate of movement of ground water contamination. (Discussed in Section 5.0).

4. Further characterize background values for ground water, surface water, and soils. (Discussed in the Risk Assessment).

5. Evaluate the hydrogeologic relationships between the surface water, ground water in the unconsolidated sediments, and the ground water in the shallow bedrock units. (Discussed in Section 4.0).

6. Better characterize contamination of soils and ground water at the buried waste lagoon, ponds and the active landfill. (Discussed in Section 5.0).

7. Determine the volume of waste in the buried lagoon. (Discussed briefly in Section 5.0 and more thoroughly in the FS).

8. Design a network of wells to be used for long term monitoring during and following the implementation of site remediation. (A ground water monitoring program will be developed and implemented concurrently with the Remedial Action Plan.)

1.2 SITE BACKGROUND

The Skinner Landfill is located approximately 15 miles north of Cincinnati, Ohio, in Section 22 (T3N, R2W) of Butler County. The landfill is located approximately one-half mile south of the intersection of Interstate 75 and Cincinnati-Dayton Road, and one-half mile north of the town of West Chester. A site location map is provided as Figure 1.1.

1.2.1 SITE DESCRIPTION AND SITE DEFINITION

The area under investigation consists of property owned by Elsa Skinner (Mrs. Albert Skinner) and Ray Skinner and includes the Skinner landfill and adjacent areas. Sample points were established in areas north and south of the landfill for collecting surface water, ground water and soil samples to characterize background levels and to help determine off-site risk to human health and the environment.

The Skinner property is comprised of approximately 78 acres of hilly terrain, bordered on the immediate south by the East Fork of Mill Creek. The landfill is bordered to the north by wooded land, to the east by a Consolidated Rail Corporation (Conrail) right-of-way, to the south across the East Fork of Mill Creek by agricultural and wooded land and to the west by Cincinnati-Dayton Road. A site topographic map is included as Figure 1.2. The principal residential area is west of the landfill; however, numerous residences are located within 2,000 feet of the landfill to the east, south and west.

1.2.2 SITE HISTORY AND CHRONOLOGY

The Skinner property, originally a sand and gravel operation, first became involved in landfill operations in 1934 with the disposal of general municipal refuse in abandoned sand and gravel pits. The precise location of these early fill areas is not known. It is unknown exactly what materials were deposited in the landfill from 1934 until the present.

In 1959, the landfill was used for the disposal of scrap metal and general trash from a paper manufacturing plant. In the spring of 1963, the Butler County Board of Health (BCBH) approved the use of the site as a sanitary landfill. In 1963, during the permitting procedure, local residents opposed the landfill, stating that chemical wastes were being dumped there.

It was revealed during a phone conversation on April 26, 1976 between Mr. Bill Kovacs of Chem-Dyne and Mr. Elmer Rehme, Chief of the Industrial Waste Section, Ohio EPA, SWDO, that Mr. Albert Skinner built and repaired tanks for C.D.C. (Chem-Dyne Company). This information was taken from a report to Mr. Ned Williams, Director, Ohio EPA, by Mr. Joe Moore, Ohio EPA.

Also in April of 1976, numerous citizen complaints and a fireman's observation, while fighting a fire at the Skinner Landfill, of a black, oily liquid in a waste lagoon on the site prompted the Ohio Environmental Protection Agency (OEPA) to investigate the Skinner Landfill. Representatives of BCBH, OEPA, the Southwestern Ohio Air Pollution Control Agency (SOAPCA) and the Butler County Sheriff's Department (BCSD), after being denied access on April 22, 1976, entered the Skinner Landfill with a search warrant on April 26, 1976. Bill Kovacs, owner/operator of Chem-Dyne, a Superfund site in

Hamilton, Ohio was also on-site at this time. According to the U.S. EPA's Regional Project Manager (RPM) responsible for this site investigation, Mr. Kovacs' role was as a consultant and advisor to the Skinners. During this site visit the waste lagoon area showed evidence of recent grading. Over one hundred 55-gallon drums marked "Chemical Waste" were observed. In verification of these observations, OEPA inspection of aerial photos taken in January and February of 1976 revealed a lagoon in the regraded area and several hundred drums scattered throughout the site.

The OEPA returned to the Skinner Landfill with a search warrant on May 4, 1976. The road leading to the waste lagoon was blocked by a bulldozer, claimed to be inoperable by Mr. Albert Skinner. When told that the OEPA would return with equipment to remove the bulldozer, Mr. Albert Skinner stated that the following materials were buried at the landfill: nerve gas, mustard gas, incendiary bombs, phosphorus, flame throwers, cyanide ash and explosive devices. At this time the OEPA withdrew from the site.

On May 11, 1976, representatives of the OEPA, the Army Special Unit and the BCSD entered the landfill to inspect and sample the waste lagoon area. Analysis of samples taken from a trench excavated at the lagoon site revealed pesticides, including chlordane intermediates, some volatile organic compounds and elevated concentrations of several heavy metals, as shown in Table 1.1. Appendix B contains the raw data as reported by the U.S. EPA.

In response to these discoveries, the Skinners retained H.C. Nutting Company in July 1976 to conduct a shallow geologic investigation. Records of five soil borings, drilled 9 to 16.5 feet deep in the area of the lagoon, show mixed soils consisting of sand, silt, clay and gravel with an occasional mention of "organics" and "odor detected." Copies of the boring logs are provided in Appendix A of this report.

The OEPA made a subsequent site inspection in July 1977. WESTON's Phase I Work Plan states that the OEPA found leachate seeping from near the buried lagoon and a faint chemical odor near the buried lagoon. From August 1977 until January 1979, OEPA attempted without success to obtain a court order to force the Skinners to remove the chemical waste. Subsequent appeals by the OEPA were unsuccessful. The court did, however, prohibit future disposal of industrial waste at this site except under legal permit. It was confirmed at this time that the Skinners had an agreement with Bill Kovacs to clean and maintain Chem-Dyne vehicles and tanks.

In early 1980, a Field Investigation Team (FIT) from CH2M Hill tried to enter the landfill to install monitoring wells and to take samples but was refused entry by Mrs. Elsa Skinner.

In July 1982, a Field Investigation Team (FIT) from CH2M Hill installed four ground water monitoring wells to characterize water quality beneath the buried lagoon area. Volatile organic compounds were detected in ground water collected from a monitoring well located southeast of the buried lagoon. In December 1982, as a result of the FIT investigation, the Skinner Landfill was placed on the National Priority List (NPL) with a ranking of 659. This action prompted the initiation of a RI/FS with Phase I activities commenced by Roy F. Weston, Inc. (WESTON) in September 1984.

In the Spring of 1986, WESTON initiated the field investigation for Phase I of the RI. This initial investigation included a geophysical survey, the installation of eighteen ground water monitoring wells, and the sampling of ground water, surface water, and soils. Additionally, a biological survey of the diversity of both fish and macroinvertibrate fauna collected from the East Fork of Mill Creek and Skinner Creek was performed.

A second round of ground water, surface water, and soil sampling was taken in the summer of 1986. Based upon the results of sampling during rounds I and II, an additional round of sampling was performed in July 1987 in accordance with the recommendations outlined in the Phase I Tech Memo, submitted by WWES in October, 1990. A soil gas survey was also performed in the vicinity of the buried lagoon in an attempt to define specific areas needing further exploration.

Since the time WWES began planning Phase II of the RI investigation and apparently also throughout Phase I activities, site access problems have occurred. Although eventually resolved, these situations served to delay the start-up of the Phase II activities. Ultimately an administrative order to permit access to the U.S. EPA and it's subcontractors was issued in October 1987 to prevent future disruption in the work schedule. Additionally, the OEPA sought and achieved site closure to all landfilling activities.

1.3 PRE-PHASE I DATA

Disposal activity at the Skinner Landfill increased in the early 1960's following BCBH approval to operate as a sanitary landfill. In 1963 citizens opposed the operation of the Skinner Landfill because industrial wastes were being disposed on the site. The conclusion that industrial wastes were being disposed of on-site was supported in a deposition given by John Skinner on May 23, 1978. On page 23 of the deposition, he stated that he dumped and buried barrels of pigment in the lagoon when he was under permit from the Butler County Board of Health.

WESTON's Work Plan (1985) reported that in May 1976, in response to statements that military ordnance were being disposed of at the Skinner site, an official of the Hamilton County Health Department and a former public official of Reading, Ohio "confirmed only that cyanide ash, phosphorus and one or two flame throwers with canisters had been disposed of by the Skinners."

Aerial photos taken in 1976 indicate a lagoon, several ponds and piles of drums were present on the site. Hazardous material was revealed in sludge samples taken from trenches dug in 1976 by the OEPA in the area of the buried lagoon. Analysis of sludge from the buried lagoon and of drum liquids detected pesticides, including chlordane intermediates, some volatile organic compounds and heavy metals. The results of these analyses are summarized in Table 1.1 and also listed in Appendix B.

Subsequent investigations by the FIT and the Technical Assurance Team (TAT) also indicated hazardous constituents were present in the ground water, drums and soils at the Skinner Landfill site. Although four wells were installed (ATEC wells B-5, B-6, B-7, B-8, Appendix A), only the two south (B-5, B-6) of the buried lagoon were sampled, the other two wells were reported to be dry. Only B-5 and B-8 are still in existence, B-6 and B-7 have apparently since been buried with construction debris. The analytical results of a ground water sample collected from the monitoring well located southeast of the buried lagoon (B-6) revealed seventeen volatile and semi-volatile organic compounds. Ground water from the monitoring well located southwest of the buried lagoon (B-5) contained only one of these same seventeen compounds, suggesting ground water flows from the lagoon to the southeast. Subsequent water level measurements support this suggestion. Well logs included in the FIT report accompany this report in Appendix A. Results of ground water samples collected in July 1982 by the FIT team are summarized in Table 1.2 and listed in Appendix B.

The U.S. EPA Emergency Response Section, at the bidding of the U.S EPA Remedial Project Manager, requested WESTON's TAT to perform a site assessment of the Skinner Landfill in February and March of 1986. Among their finds are analysis of media termed "lagoon seep, lagoon runoff, dump seep and dump runoff" which revealed the presence of volatile and semi-volatile organics in these media. A sample of drummed liquid located on the landfill north boundary contained 15 ppb benzene and 3800 ppb toluene with a flash point of 82 degrees F. Soil collected adjacent to Skinner Creek contained 3580 ppb 2-chlorethyl ether, 294 ppb chloroform and 11 ppb ethyl benzene. Five ground water samples collected from the Skinner Landfill contained volatile organics, semi-volatile organics and elevated concentrations of arsenic and zinc. Detected volatile organic compounds include benzene (1270 ppb), 1-1dichloroethane (1960 ppb), 1-2-dichloropropane (1376 ppb), methylene chloride (1104 ppb) and toluene (3393 ppb). The locations of these sampling points were not documented but appear to correspond to the three former FIT wells and the two Skinner residential wells. These data are summarized in Tables 1.3, 1.4, and 1.5. A sampling location map was not included with this report.

1.4 SUMMARY OF PHASE I RI

WESTON began a comprehensive investigation of the Skinner Landfill, presenting their initial findings in the Phase I Interim Investigation Report of December 1988. The major portion of WESTON's Phase I field activities took place in the spring of 1986. These activities consisted of geophysical surveys; construction of monitoring wells; chemical analysis of ground water, surface water, stream sediment and soil samples; and a biological survey of both Skinner Creek and the East Fork of Mill Creek. A second round of ground water sampling was performed in the fall of 1986 followed by a third sampling event, conducted in July 1987, which included ground water, surface water, stream sediment and soil sampling. The results of this third round of sampling were not incorporated into the Phase I Interim Report. WWES summarized the results of the third round of sampling in the Phase I Technical Memorandum submitted in October, 1990. Chemical data collected from the site prior to the Phase II investigation by WWES is contained in Appendix B. Sample location maps (where available) are included with the analytical data in Appendix B.

1.4.1 Geophysical Surveys

Ten seismic refraction lines were completed to determine the depth to bedrock. WESTON interpreted the data to show the depth to bedrock varying between 11 to 80 feet below the ground surface and that, in general, the bedrock topography mirrors the surface topography of the site.

Electromagnetic surveys were conducted near the buried lagoon, northwest of the buried lagoon and adjacent to the East Fork of Mill Creek. Due to the abundant occurrence of metal debris on the ground surface, the data from northwest of the buried lagoon was inconclusive and not incorporated into the Phase I Interim Report. Several "hot spots" were detected in the buried lagoon area with recorded conductivities consistent with what would be expected from buried metal debris. The survey performed adjacent to the East Fork of Mill Creek did not reveal buried metal debris but elevated conductivities noted in several locations could be attributed to either leachate migration or to natural conductivity changes related to variations in soil type.

A ground penetrating radar (GPR) study of the buried lagoon revealed eight potential drum nests with one such nest located northwest of the lagoon. The surveys also detected other buried objects in the lagoon area and ten other possible buried objects to the northwest of the lagoon.

A magnetometer survey was conducted to supplement the GPR in the lagoon area and to the northwest of the lagoon. Contours of the magnetic gradient indicate two anomalies with the resulting magnetometer data generally outlining the buried lagoon.

1.4.2 Monitoring Wells

Eighteen monitoring wells were installed in May of 1986, including three wells screened at or near the top of the bedrock. The remaining wells were constructed in the unconsolidated sediments and the well screens were placed to straddle the water table as it occurred at that time. Two of the wells, GW13 and GW08, were reported dry in August 1986 and July 1987 probably due to subsequent changes in water table elevation.

Ground water elevations as measured in the wells in the vicinity of the buried lagoon on May 13, 1986, indicated a flow towards the southeast. There was also a discernable downward vertical gradient observed when comparing ground water elevation measured in wells screened shallow in the unconsolidated sediments as opposed to those wells screened deeper in the bedrock. Ground water flow patterns in the bedrock were not determined. The hydraulic relationship between ground water elevations and surface water elevations observed in the East Fork of Mill Creek and Skinner Creek were not determinable from Phase I data.

Ground water samples were collected and analyzed in the spring and summer of 1986 and in the summer of 1987. Chemical parameters analyzed included volatile organic compounds, semi-volatile organic compounds, inorganic compounds, pesticides and PCB's. Tables summarizing the results of these sampling events are contained in Appendix B.

Ground water downgradient from the buried lagoon and beneath the active landfill was demonstrated to be impacted by volatile, semi-volatile and inorganic compounds. Acetone, toluene and benzene were consistently detected in GW20 and GW22. The acetone concentration in GW20 was 5.9 ppm and a benzene concentration of 20 ppm in GW22 was detected in the August 19, 1986 sampling event. Ground water from GW22 also contained elevated levels of total xylenes and 1,2-dichloroethane. Both wells were screened in the unconsolidated sediments.

Compounds detected in ground water above the primary Maximum Contaminant Levels (MCL's), stipulated by the Safe Drinking Water Act, included benzene, carbon tetrachloride, tetrachloroethane, vinyl chloride, 1,4-dichlorobenzene, pentachlorophenol and barium. Iron, manganese and aluminum concentrations exceeded secondary MCL levels established to protect the aesthetic qualities of drinking water.

Although the majority of the contamination existed in the shallow wells, benzene, tetrachloroethane, pentachlorophenol and trans-1,2-dichlorethene were found in the bedrock wells. Some contaminants appeared to be moving into the bedrock.

Low levels of pesticides were detected in the ground water collected during the second round of sampling only. No PCB's were detected by any of the Phase I ground water sampling events.

1.4.3 Residential Wells

WESTON sampled seven residential wells in August 1986 as part of the Phase I RI. Two of the seven wells, RW06 and RW10 located in the southern direction from the buried waste lagoon, were not operational but did contain standing water which was sampled.

Volatile organic compounds were detected in RW03 and RW10 but the validity of the analysis was suspect due to the presence of the same compounds, acetone and 1,1,1-trichloroethane, in the field blanks. Chloroform and bromodichlormethane were present in RW03 below the MCL.

Semi-volatile organic compounds were detected at low levels in RW02 and RW10 but no drinking water standards exist for the particular compounds detected. Pesticides were detected in all of the residential wells except RW01. Proposed MCL's were exceeded for the following compounds: heptachlor, heptachlor epoxide, and PCB Aroclor 1254.

The standing water in the two non-operational residential wells contained elevated levels of iron, aluminum, zinc, manganese and calcium. Several of the operating wells also had elevated levels of iron and manganese. Secondary MCL's were exceeded for chloride, iron and manganese in both of these wells.

No well construction details were provided for the residential wells sampled during Phase I; therefore, it could not be determined whether the chemical parameters detected in the wells were derived from a source related to the Skinner Landfill.

1.4.4 Surface Water and Sediment

Two rounds of surface water, leachate, and stream or pond sediment sampling were undertaken during May of 1986 and July of 1987. Surface water and sediment samples were taken from 15 locations in May of 1986. The 1987 sampling event was more limited in scope, one surface water and two sediment samples were collected.

Samples collected from the East Fork of Mill Creek and Skinner Creek contained low levels of 2-butanone, acetone and methylene chloride. The validity of these results was suspect due to similar low levels detected in the associated laboratory blanks. Surface water and sediment samples collected from the ponds on site and from an unnamed tributary, emanating from the active landfill area, had similar validity problems. However, two sediment samples collected from the ponds located in the western portion of the site contained elevated levels of 1,1-dichlorethane, benzene, ethylbenzene and total xylenes.

Semi-volatile organic compounds in the surface water did not appear to be a cause for concern due to low to non-detectable concentrations. However, many semi-volatile organic compounds were detected in the sediment samples. A complete list of semi-volatile compounds detected in surface water samples is contained in Appendix B.

Pesticide and PCB compounds were not detected in any surface water sample but were discovered in sediment samples collected from Skinner Creek, the western ponds, and from a leachate sample collected adjacent to the active landfill. A sediment sample collected from the northernmost pond adjacent to Skinner Creek contained 442 ppb of Aroclor 1260.

Elevated concentrations of aluminum and iron were detected in most of the surface water and sediment samples collected. Barium was present at elevated concentrations in leachate samples and in samples from the most downstream sampling location. Elevated concentrations of manganese and zinc were also present in most of the sediment samples.

1.4.5 SURFACE SOILS

Soil samples were collected in the spring of 1986 (10 on-site and 3 off-site) and in July of 1987 (2 background). Appendix B contains the soil sampling results and a sample location map.

A total of 8 volatile organic compounds (VOC) were detected in the surface soils samples collected during the 1986 sampling event. The most significant concentration detected in the 0 to 6 inch interval was toluene with a concentration of 2,500 ppb at SS12, originally designated as a background sample. No other VOC compounds were considered significant by WESTON.

The highest concentration of total semi-volatile organic compounds in the surface soil (0 to 6 inches) was found at locations SS03-01 and SS05-01 with concentrations of 40,240 ppb and 62,350 ppb, respectively. The greatest concentration of a specific semi-volatile compound detected in the 0 to 6 inch sample was 23,000 ppb of hexachlorobenzene in SS05-01. Surface soil samples SS03 and SS05 were both located adjacent to storage tank disposal areas. The most common compounds detected in the 0 to 6 inch interval were fluoranthene and pyrene which were both detected at eight discrete locations.

Total semi-volatile organic compound concentrations in the near-surface soils (12 to 18 inches) ranged from 0 to 2,030 ppb. The highest cumulative concentrations were found at SS02-02 and SS05-02 with concentrations of 2,030 ppb and 1,890 ppb, respectively. All concentrations in the 12 to 18 inch interval were considerably less than in the corresponding 0 to 6 inch interval. The one exception was at sample location SS06 where the bis(2-ethyl hexyl) phthalate concentration increased from not detected to an estimated concentration of 160 ppb.

No pesticides were detected in the surface soil samples, but PCB Aroclor 1254 was found at location SS07 in the active landfill area. The Aroclor was detected in both depth intervals sampled (0 to 6 inches and 12 to 18 inches) with a concentration of 980 ppb. Sample SS07 also showed elevated levels of cadmium, copper, lead and mercury. Low levels of cyanide were detected at sample locations SS07 and SS08 with concentrations of 1.6 mg/kg and 1.8 mg/kg, respectively in the 0 to 6 inch samples.

1.4.6 Soil Gas Survey

A soil gas survey was conducted by WESTON in April 1987 using a portable ambient air analyzer. Upon arrival at the site, it was discovered that the majority of the proposed study area had been covered with 5 to 20 feet of demolition debris and solid waste. The fill had covered both the existing site grid system and the proposed soil probe locations. This necessitated a revision in the anticipated scope of work.

The southern-most portion of the central shoulder and buried lagoon areas were covered with fill to a maximum thickness of approximately 10 feet. It was decided by the U.S. EPA RPM and the WESTON Site Manager to conduct the soil gas survey in this area.

The results of the soil gas survey are contained in Appendix C. Nineteen soil probes were placed within a rectangular grid approximately covering the buried lagoon area. Probes were placed in locations coinciding with areas of possible contamination as inferred by the GPR and EM surveys. Soils gas analyses were conducted for benzene, toluene and methylene chloride.

The results of the survey were summarized in a technical memorandum submitted to the U.S. EPA on May 12, 1987.

The results of the survey indicated that zones of elevated soil vapors occurred as a series of "hot spots" as opposed to any definable trend. Concentrations of benzene contained in the soil gas ranged from 1.2 to 50 ppm, toluene from 1.7 to 768 ppm and methylene chloride from 2.2 to 868 ppm. The areas identified as having the highest concentration of one or more volatile compounds occurred in the northwest and western portion of the buried lagoon area. The scattered nature of the identified "hot spots" were taken under consideration during the formulation of the grid system for soil boring placements to investigate the waste lagoon undertaken during Phase II RI activities in the spring of 1990. Figure 1.3 is a summary of the Phase I investigation results in the waste lagoon area.

1.4.7 Buried Lagoon Investigation

An exploration of the buried lagoon area stratigraphy and chemistry was planned as part of the Phase I investigation. This investigation was planned, including the subcontracting of the drilling, prior to the placement of the demo fill material but was subsequently cancelled due to the changes in site conditions in the buried lagoon area. The drilling and sampling were again recommended in the Phase I Interim RI (December 1988).

1.5 DATA GAPS

Based on the prior investigations at the Skinner Site and WESTON's suggestions for further work, WWES determined that the following site characteristics needed to be further investigated (Phase II) before performing an assessment on the affect of known contaminants and the identification of remedial alternatives:

- The pathway of contamination migration into the shallow bedrock units underlying the site.
- The extent of shallow bedrock contamination.
- Ground water elevation data for the western portion of the site.
- The estimated extent and rate of migration of contamination off-site.
- The hydrogeologic relationships between the surface water, ground water in the unconsolidated portion of the aquifer, and the ground water in the shallow bedrock portion of the aquifer.
- The lateral extent of contamination (if any) to residential wells in the immediate area.
- The volume of waste in the buried lagoon.

1.6 REPORT ORGANIZATION

The remainder of this remedial investigation report (Phase II RI) is divided into five principal sections. Section 2 presents the investigative methods used and the sampling locations chosen during the Phase II investigation and describes any deviations from the Phase II QAPP. Section 3 describes the geologic setting of the Skinner site. Section 4 discusses the hydrogeologic setting of the Skinner site, including both surface and ground water and their interrelationships. Section 5 presents and discusses the results of the chemical analyses resulting from samples collected during the investigation. Section 6 summarizes the interpretations and presents the conclusions of the remedial investigation.

SECTION 1

TABLES

Table 1.1
Hazardous Chemicals Detected in a Trench
Skinner Landfill, May 1976

Organic Compounds*

Major Constituents

- Octachlorocyclopentene
- Napthalene
- Heptachloronorborene
- Hexachlorobenzene
- Chlordane

Minor Constituents

- Hexachlorocyclopentadiene
- Methyl Naphthalene
- Isobutyl Benzoate
- Hexachloronorbornadiene
- Trichloropropane
- Dichlorobenzene
- 1,3 Hexachlorobutadiene
- Octachlor penta fulvalene
- Benzoic Acid

Inorganic Compounds (maximum concentrations, ppm)

- Phenols (27.3)
- Cyanide (761)
- Cadmium (350)
- Lead (1370)
- Zinc (480)
- Copper (1840)
- Mercury (0.075)

* Qualitative determination by GC/MS. Original Report contained in Appendix B.

Table 1.2
Hazardous Chemicals Detected in Monitoring Wells
Skinner Landfill, July 1982

	B-6 *	B-5 *
Bis-(2-chloroisopropyl)ether	350 ppb	ND
Benzene	79 ppb	ND
1,2-Dichloroethane	163 ppb	ND
1,1,1-Trichloroethane	13 ppb	ND
1,1-Dichloroethane	131 ppb	ND
1,1,2-Trichloroethane	<10 ppb	ND
Chloroethane	35 ppb	ND
Chloroform	17 ppb	ND
Trans-1,2-Dichloroethylene	60 ppb	ND
1,2-Dichloropropane	283 ppb	<10 ppb
Ethyl Benzene	<10 ppb	ND
Methylene Chloride	17 ppb	ND
Toluene	450 ppb	ND
Trichloroethylene	<10 ppb	ND
Vinyl Chloride	24 ppb	ND
Naphthalene	<10 ppb	ND
Diethyl Phthalate	<10 ppb	ND

* - Well B-6 is located SE of the buried lagoon, Well B-5 is located SW of the buried lagoon.
ND - Not Detected

Table 1.3
Analytical Results of Samples Collected by the TAT*
at Skinner Landfill
West Chester, Ohio
February 20, 1986
(results in parts per billion)

Compound	Lagoon Seep #50	Lagoon Runoff #53	Dump Seep #51	Dump Runoff #52	Lime Lagoon #1	North East Drum Pile #2	Soil by Skinner Creek #3
Benzene	-	-	-	-	NA	15.07**	-
2-Chloroethylvinyl Ether	39.48	92.9	45.77	22.32	NA	-	3580.08
Chloroform	3.67	-	4.84	2.19	NA	-	294.73
Trans-1,3-Dichloropropane	-	-	-	-	NA	-	4.61
Ethyl Benzene	-	3.76	-	-	NA	3403.50**	11.39**
Methylene Chloride	37.01	12.51	82.52	54.67	NA	-	-
Toluene	40.41	125.82	59.17	77.22	NA	3803.80**	-
1,1,1-Trichloroethane	39.19	52.15	31.85	33.79	NA	-	-
Trichloroethene	-	54.88	-	-	NA	-	-
Anthracene	-	-	-	1.13	NA	NA	NA
Phenanthrene	-	-	-	1.18	NA	NA	NA
EP Toxicity (results in ppm)							
Arsenic	0.12**	-	0.007**	0.006**	0.001**	NA	NA
Barium	-	-	-	-	3.0**	NA	NA
Chromium - Total	0.33	-	0.13	-	-	NA	NA
Copper	0.11	-	-	-	NA	NA	NA
Lead	0.28	-	-	-	-	NA	NA
Mercury	0.19	-	-	-	-	NA	NA
Nickel	0.2	-	-	-	NA	NA	NA
Zinc	0.88	-	-	-	NA	-	NA
Flash Point	NA	NA	NA	NA	>212 deg. F	82 deg. F	NA

* Samples Analyzed by Surburban Labortories, Inc., Hillside, Illinois
- Below Detection Limit
NA Not Analyzed
** Concentrations reported in parts per million

Table 1.4
Analytical Results of Samples Collected by the TAT*
at Skinner Landfill
West Chester, Ohio
February 20, 1986
(results in parts per billon)

Compound	Well #54	Well #55D	Well #56	Field Blank
Benzene	1163.39	1270.37	8.66	-
Chlorobenzene	62.49	75.46	-	-
Chloroethane	288.61	343.38	-	-
Chloroform	59.36	70.21	122.37	5.93
1,3 Dichlorobenzene	756.24	586.48	-	-
1,4 Dichlorobenzene	111.11	-	-	-
1,1 Dichloroethane	1780.31	1963.23	-	-
1,2 Dichloroethane	65.48	101.84	-	-
1,1 Dichloroethene	20.43	35.66	22.97	-
Trans 1,2 Dichloroethene	788.32	968.22	-	-
1,2 Dichloropropane	805.54	1376.18	-	-
Ethyl Benzene	181.4	215.82	7.3	-
Methylene Chloride	295.06	516.79	1104.69	36.22
Toluene	3231.65	3393.95	381.62	44.79
1,1,1 Trichloroethane	176.75	274.89	293.65	24.06
Trichlorethene	25.01	14.73	29.02	-
Phenol	14.1	-	-	-
2-Chlorophenol	6.27	-	-	-
Bis (2-chloroethyl) Ether	315.61	313.18	-	-
Bis (2-Ethylhexyl) Phthalate	32.34	61.78	4.68	1.1
Naphthalene	12.38	16.25	-	-
Arsenic	20	30	NA	-
Zinc	230	180	NA	-

* Samples analyzed by Suburban Laboratories, Inc., Hillside, Illinois
- Below Detection Limit
NA Not Analyzed

Table 1.5
Analytical Results of Samples Collected by the TAT*
at Skinner Landfill
West Chester, Ohio
March 14, 1986
(results in parts per bilion)

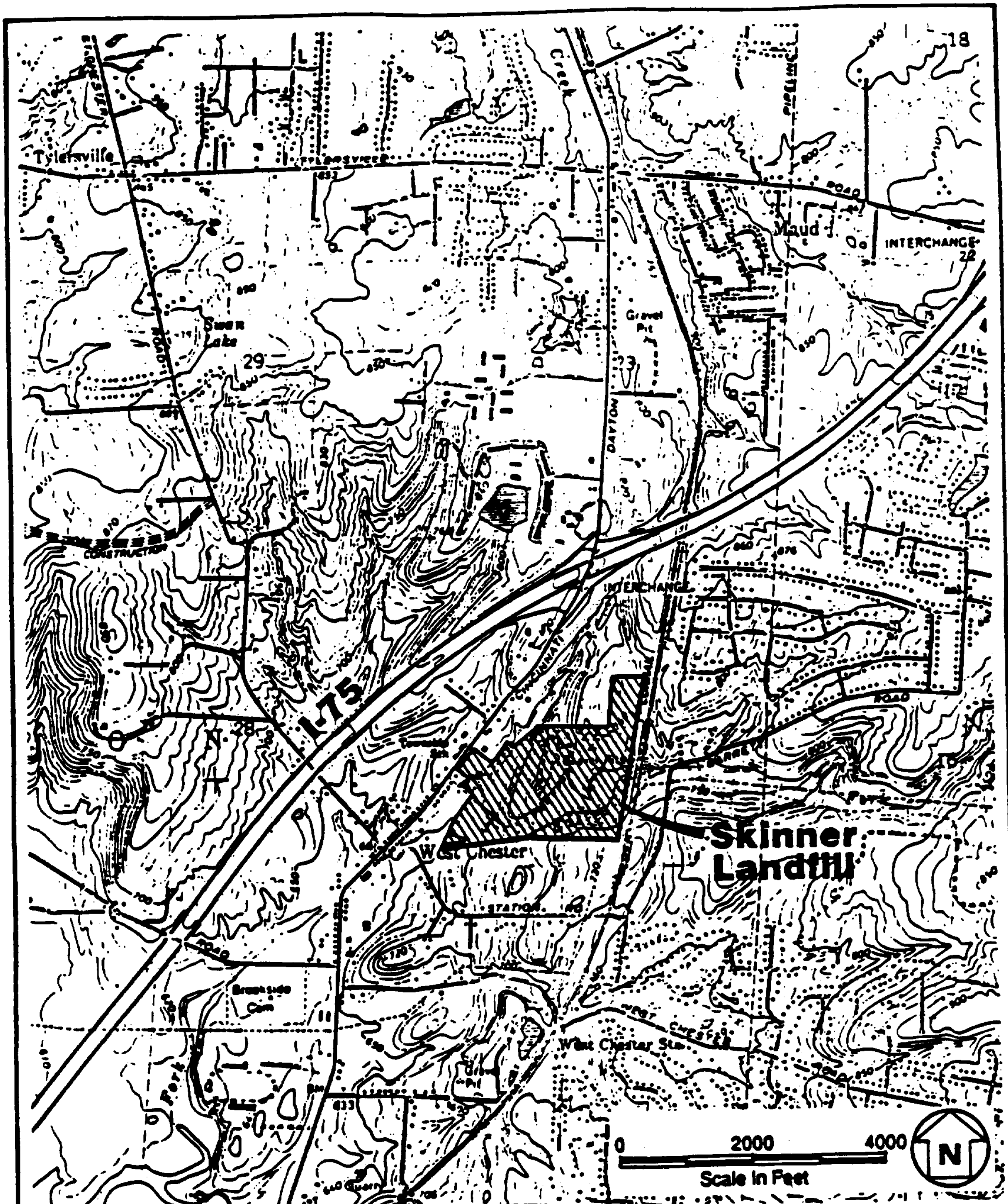
Compound	S61 Lagoon Well	S62 Skinner Well	S64 Field Blank
1,1 Dichloroethane	3	-	-
1,2 Dichloroethane	5	-	-
1,1,1 Trichloroethane	20	14	-

* Samples analyzed by Canton Analytical Laboratory, Inc.,
Ypsilanti, Michgan

- Below Detection Limit

SECTION 1

FIGURES



Map copied in part from USGS Glendale Quadrangle (7.5 minute)

Figure 1.1

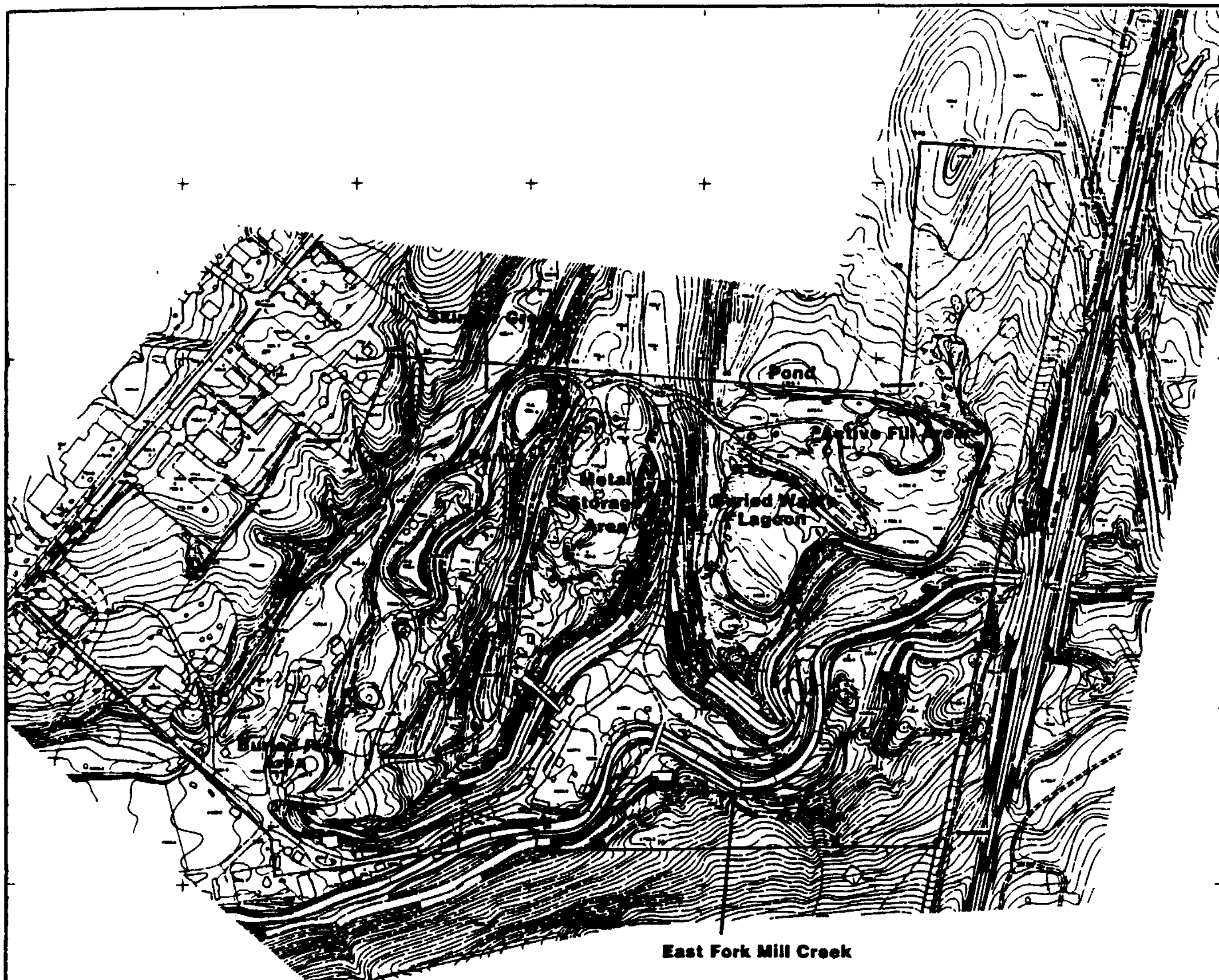
Site Location Map

Skinner Landfill

West Chester, Ohio

February, 1989 04003.01

WW Engineering & Science



N

0 150 300 600

Scale in Feet

Figure 1.2, 3.1

Topographic Map

SKINNER LANDFILL

West Chester Ohio

March, 1991

04003 15

WW Engineering & Science

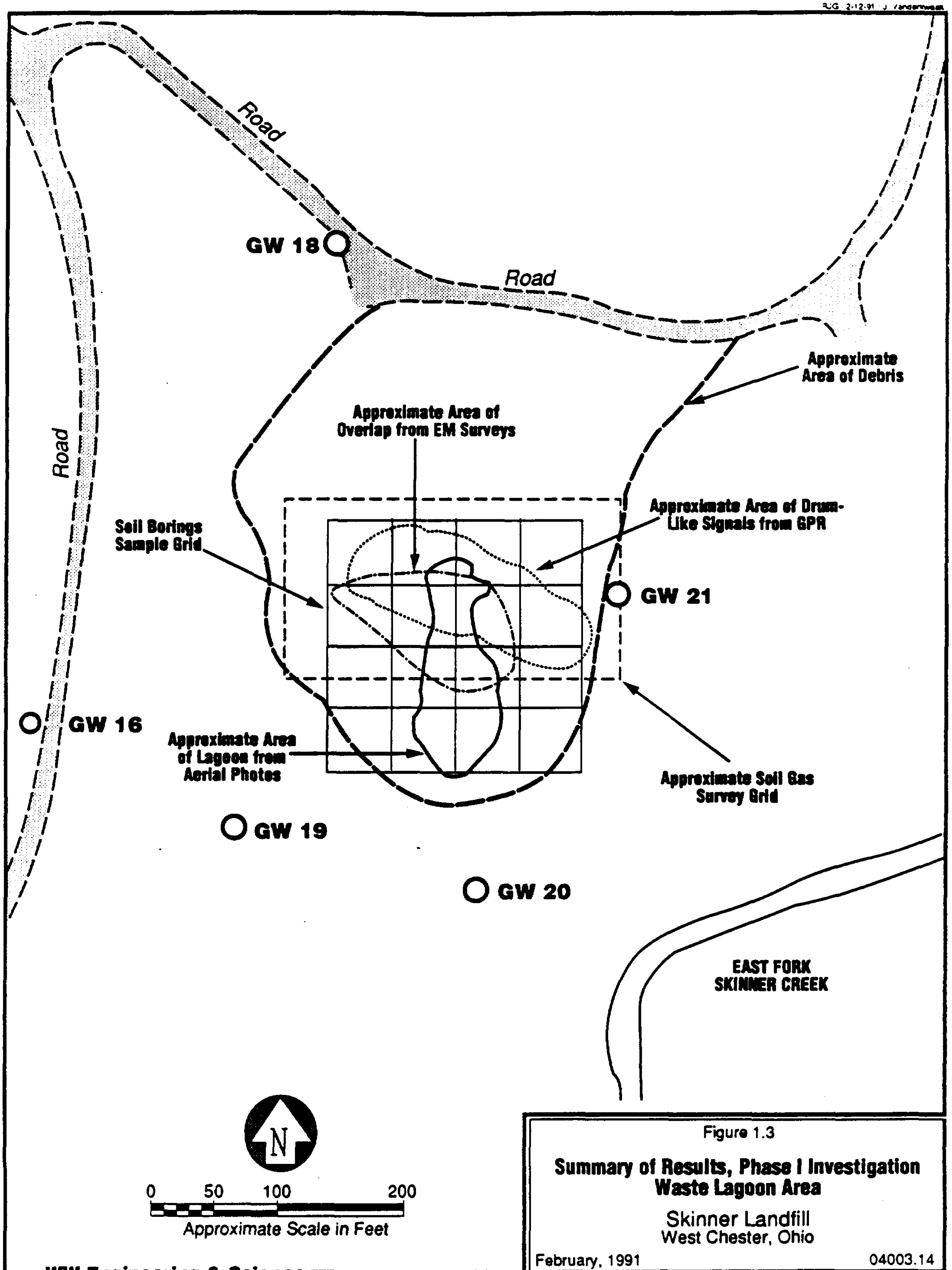


Figure 1.3

Summary of Results, Phase I Investigation Waste Lagoon Area

Skinner Landfill
West Chester, Ohio

February, 1991 04003.14

2.0 SITE INVESTIGATION METHODS

This section describes the methods and procedures used by WWES during the Phase II remedial investigation to collect geologic and hydrogeologic data and sample environmental media. The following activities are specifically described:

- Surface water, sediment, and leachate sample collection
- Hand auger sample collection
- Soil boring techniques
- Monitor well installation
- Borehole geophysics
- *In situ* hydraulic conductivity measurement
- Ground water sample collection
- Database development
- Monitor well abandonment
- Residential well sampling
- Ground water level measurement
- Site survey

Any deviations from the proposed work methods are also discussed in this section. Table 2.1 indicates the sample labeling scheme used during the Phase II sampling program.

2.1 SURFACE WATER, SEDIMENT AND LEACHATE SAMPLING

Three sampling tasks were conducted following the "Sampling Plan for the Remedial Investigation and Feasibility Study of the Skinner Landfill Site" (September, 1989) and the "Quality Assurance Project Plan for the Remedial Investigation and Feasibility Study of the Skinner Landfill Site" (September, 1989). Some minor departures from these plans were required by changed site conditions. This section documents these changes in addition to providing details on the sampling.

The most significant change in site conditions that occurred between the time the sampling and quality assurance plans were prepared was the elimination of one pond and the combining of two other ponds that had been scheduled for surface water and sediment sampling. It was not possible to sample these ponds as scheduled and proposed, so samples were collected from other locations. Some minor changes in sampling techniques were made to adjust to site specific conditions. These changes are detailed in the Methods section.

Figure 2.1 indicates the proposed sampling locations in the ponds and shows the surface topography and ponds in existence prior to the Skinner's alterations. The topographic changes resulted in the combining of two ponds to form what has been called Trilobite Pond. The samples taken from Trilobite Pond during the Phase II sampling should reveal any contaminants present in the other pond prior to the alterations. The area where the third pond was located had been leveled and the unconsolidated sediments removed to bedrock in a gravel/sand mining operation. Figure 2.2 indicates the Phase II sampling locations in the ponds and shows the current topography in the pond area.

2.1.1 SITE CONDITIONS AND SAMPLE LOCATIONS

Sediments and surface water from three creeks, three ponds, and three leachate seepage areas were sampled. Figure 2.2 is a map of the site and includes these features and the sampling locations.

The creeks included the East Fork Mill Creek (referred to as Mill Creek), Skinner Creek, and a very small creek on the east side of the active landfill area (referred to as Dump Creek for convenience). Dump Creek divides into east, middle, and west branches.

The ponds included a pond to the north of the active landfill area and north of the Skinner Landfill property and two ponds along Skinner Creek on the west side of the site. The pond north of the landfill is referred to as "Duck Pond," the northern pond along Skinner Creek is referred to as "Diving Pond," and the southern pond along Skinner Creek is referred to as "Trilobite Pond." These names were assigned for convenience in referring to the sampling areas.

Two leachate seepage areas along Mill Creek and one area along Skinner Creek were sampled. The seepage areas along Mill Creek had been identified in the Phase I study and were included in the Sampling Plan for the Phase II study. The seepage area sampled along Skinner Creek was identified during implementation of the Phase II study.

2.1.2 SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

Some minor modifications in the surface water and sediment sampling locations were made at Skinner Landfill based on new conditions at the site.

Two of the ponds on the west side of the site have been altered. One has been eliminated and two others have been combined to form one pond. The topographical alterations are the result of excavation activities conducted by the landfill operator, Ray Skinner, in late 1989.

An additional seepage area (LS/LW03), previously unidentified, was located along Skinner Creek near Trilobite Pond. The sediments in this seepage area had a very strong fuel odor and were apparently contaminated with oils. Two seepage areas along Mill Creek, identified during Phase I, were located and sampled.

Four sampling locations were added to Mill Creek, and one was added in the seepage area in Skinner Creek. Sediment samples were added to all the leachate seep areas. The new locations in Mill Creek are in depositional areas where fine sediments, likely to adsorb contaminants, have accumulated. Most of the creek is well scoured and there are not very many depositional areas near the site.

The changes in sampling locations did not change the total number of samples specified in the Sampling and Quality Assurance Plans.

Surface water sampling locations are shown in Figure 2.2. Surface water and sediment samples were collected at the same locations, except for two locations, one on Skinner Creek (SF-37) and the other on East Fork of Mill Creek (SF-36), where only surface water was collected. Surface water sample designations are prefixed with "SF" and sediment samples are prefixed with "SM." Water samples from the Trilobite pond were collected from two depths, designated A and B. The "A" samples were collected from near the surface and the "B" samples were collected from near the bottom. No sediments were collected from the "A" samples.

2.1.3 LEACHATE SAMPLING LOCATIONS

Leachate samples were collected from three locations. Sediment samples were also collected at these locations, which was not specified in the Sampling Plan. The leachate water samples are prefixed with "LW," and the sediment samples at leachate locations are prefixed with "LS."

2.1.4 METHODS

2.1.4.1 Surface Water Sampling

Surface water samples were collected as specified in the Sampling Plan.

2.1.4.2 Sediment Sampling

Sediment samples were collected from the creeks with a stainless steel trowel. Sufficient sample was collected to fill all the samples bottles and was placed in a stainless steel pan for mixing. Samples for volatile organic compound analyses were placed into the sample bottles from the pan before the sediments were mixed to minimize the loss of these chemicals due to volatilization. The sediments were then thoroughly mixed and placed into the sample bottle using the trowel. The stainless steel mixing pan and stainless steel trowel were decontaminated as specified in the Quality Assurance Plan. Field blanks were collected by pouring white silica sand into the mixing pan and mixing the sand with the trowel. The sand was then poured into the appropriate sample bottles. Use of sand for the field blanks was an approved departure from the Quality Assurance Plan, which specified use of water for sediment field blanks.

Sediment samples from the ponds were collected with a "Petite Ponar" as specified in the Sampling Plan.

2.1.4.3 Leachate Sampling

Samples of leachate water were collected by digging a small hole in the bank where the seepage occurred. Water in the hole was allowed to clear for several days and then the water was collected by submerging sample bottles in the water in the collection hole. This is the collection method specified in the work plan.

Leachate sediment samples were collected in the same manner as sediment samples from the creeks. Samples were taken after the accompanying water samples from within the seepage zone.

2.1.4.4 Field Measurements

Field measurements of surface water were made as specified in the Sampling Plan. Temperature, pH, and specific conductance were measured in the water samples. HNu readings were made of sediment samples. A summary of field measurements for surface water and sediment samples is included as Table 2.2.

2.1.4.5 Sample Preservation and Shipping

The samples were preserved, packaged and shipped as specified in the Sampling and Quality Assurance Plan.

2.1.4.6 Analytical Methods

The samples were analyzed as specified in the Sampling Plan. Total phosphorus instead of dissolved phosphorus (as specified in the Quality Assurance Plan) was analyzed. This change was made because total phosphorus is more important in terms of potential ecological impacts on aquatic communities than is dissolved phosphorus.

2.2 HAND AUGER SOIL SAMPLING

Hand auger borings were completed at three locations as shown in Figure 2.4. These locations were positioned between the active landfill area and the Duck (north) pond. The purpose of the borings was to determine if the soil quality and subsequent surface water quality of the pond had been impacted by runoff from the landfill. Boring construction and sampling were completed as specified in the Work Plan and Quality Assurance Plan.

Investigative soil samples were collected from two discrete depth intervals at each boring location. The samples were taken from six to twelve inches, designated the "A" samples, and from eighteen to twenty-four inches below the ground surface, the "B" sample. Additionally, a duplicate sample was collected from one sample interval to evaluate the quantitative results and a field equipment blank taken to evaluate the equipment decontamination procedures. The resulting soil samples were submitted for the following analysis: RAS organics, RAS inorganics and SAS constituents which included pesticides.

All samples were collected with a 2-inch diameter stainless steel hand auger. The soil samples were removed from the auger, placed on a clean sheet of plastic and immediately transferred to the appropriate sample bottles using a stainless steel spatula.

2.3 SOIL BORINGS

As part of the Phase II RI, a total of twenty-two soil borings were installed at the buried pit and adjacent to and within the former waste lagoon.

2.3.1 BURIED PIT (BP) AND BURIED LAGOON (BL) BORINGS

Six soil borings were installed to further delineate subsurface sediment characteristics and to determine if the sediments had been impacted by past landfilling activities in two areas of the site: the buried pit, identified by comparing recent and historic aerial photos, and the buried lagoon, identified in the 1970's by local health and state officials. Figures 2.3 (BP) and 2.4 (BL) indicate the locations of these borings. Sampling and analysis were performed as specified in the Work Plan and Quality Assurance Plan.

The borings were drilled and sampled between February 6 and 14, 1990. Drilling techniques, sediment textures and apparent VOC concentrations were recorded by a field geologist on a soil boring log. Ambient air monitoring for VOC's in the breathing zone was conducted on a regular basis as dictated in the Health and Safety Plan. A record of the ambient air monitoring results and soil boring logs is included in Appendix A.

A mobile B-53 drilling rig operated by ATEC Associates, Inc. and supervised by WWES personnel was used to drill these borings. The borings were drilled using 3.25-inch hollow stem augers (HSA). A three-inch diameter stainless steel split spoon sampler was used to collect the soil samples at approximately 2.5-foot intervals between 0 and 10 feet and at 5-foot intervals thereafter. All augers, split spoons and other sampling equipment were steam cleaned between boring locations.

Each soil sample collected was screened with an HNu and/or OVA meter. If the screening registered two times above the ambient air or if the soils were visibly stained or have an unusual odor, the sample was retained for chemical analysis. The soil was immediately transferred into the appropriate containers using a decontaminated stainless steel spatula and was not composited in order to minimize exposure to the atmosphere and prevent loss of volatiles. A maximum of five and a minimum of one soil sample were selected for analysis from each borehole.

The soil samples were analyzed for RAS organics, RAS inorganics and SAS constituents including pesticides and TOC. the samples collected from the boreholes adjacent to the lagoon were also analyzed for dioxin under a SAS request. Sampled intervals were indicated on the boring logs. A summary of soil sampling intervals in each boring is included in Table 2.3.

According to the Work Plan, the buried pit borings were to be drilled to the top of the water table. However, since the water table was encountered in the first boring (BP01) at only 0.7 feet, the plan was altered to extend the borings until the sand and gravel fill material was no longer encountered. The open boreholes were sealed with cement-bentonite grout upon the completion of the sampling.

2.3.2 WASTE LAGOON (WL)

Sixteen soil borings were installed in the Waste Lagoon Area. These borings were drilled on a predetermined grid to identify the spatial extent of the buried lagoon and to identify it's contents. The borings were drilled between April 9 and May 18, 1990. A 200 by 200 foot grid was established on top of the lagoon and divided into sixteen 50 by 50 foot sections. The grid was sited using an aerial photo from 1976 showing the exposed lagoon and using the magnetometry, electromagnetic conductivity and soil gas surveys performed by WESTON during the Phase I RI as shown in Figure 1.3. Sampling began in the middle of the grid at WL06 and proceeded outward. Figure 2.4 illustrates the location of these borings.

These soil borings were installed by ATEC Associates using a Mobile Drill B-53 rig and 4.25-inch I.D. hollow stem augers. Samples were collected in three inch I.D. steel split spoons at continuous intervals once the buried lagoon was encountered. All augers, split spoons and other sampling equipment were steam cleaned between boring locations in accordance with the decontamination procedures specified in the QAPP and approved by the U.S. and Ohio EPA. The split spoons were washed with Alconox and triple rinsed with municipal water between sample intervals at each boring location.

The unique materials encountered while drilling into the waste lagoon necessitated a variation in the decontamination of the auger strings. Some of the various colored liquids encountered dried rapidly, adhering to the augers. Standard decontamination procedures could not remove the material. The augers were steam cleaned, rinsed with hexane several times, and sand-blasted at an off-site location. This modification, while removing the material, greatly slowed portions of the waste lagoon investigation.

All drilling and sampling was monitored with an HNu or equivalent instrument. Samples were collected until the soil no longer appeared contaminated: all samples that had odors, discolorations, sheen or HNu readings were retained. A maximum of three samples per auger boring was selected for chemical analysis. The waste lagoon samples were analyzed for RAS organics, RAS inorganics and additional SAS parameters. Sampled intervals are indicated on the boring logs. A summary of soil sampling intervals in each boring is included in Table 2.3.

The soil borings constructed on the waste lagoon were not abandoned as described in the site work plan. The augers were advanced to the desired depth with the auger rotation direction reversed on retrieval, forcing the cuttings back down and effectively closing the borehole. This method of abandonment was valid as the injection of grout into the abandoned boreholes could not have filled all of the void spaces in the debris pile and would have been an expensive method from both a materials and labor perspective, for questionable results. By using this method the quantity of significantly contaminated soil and waste material that was exhumed during drilling was reduced. WWES viewed this as an important health and safety consideration while working in the buried waste lagoon area.

Soils with elevated organic vapors overlying permeable soils with relatively lower organic vapor concentrations was observed in two borings within the waste lagoon, WL-06 and WL-13. WL-13 was filled with cement/bentonite grout from the bottom up and the thin permeable units encountered in WL-06 were sealed by filling the bottom 6 feet of the borehole with bentonite pellets.

Of the remaining 14 borings constructed in the waste lagoon area, WL-01, WL-02, WL-04, and WL-16 did not encounter any permeable units. The other ten borings were terminated in a clay formation where the organic vapor readings from soil samples were significantly reduced. Permeable sands and gravels encountered in these borings had significantly higher organic vapor concentrations than the overlying fill or the underlying clay soils; therefore, these permeable units were significantly contaminated at the time of drilling and not impacted by drilling or abandonment methods. Each of the borings were sealed at the ground surface to prevent any infiltration of precipitation into the borehole. The boreholes were grouted if no fill material was encountered.

The action levels for the individual contaminants are described in the site Health and Safety Plan. Any detections were noted on the Well/Boring Log Sheets.

2.3.3 Ambient Air Monitoring

During the construction of the monitoring wells and during the drilling of the soil borings, the on-site ambient air was continually monitored. The monitoring equipment and the associated measured parameter are listed below:

Combustible Gas Indicator	-	Explosive/Flammable Atmospheres
HNu PID and/or OVA	-	Organic and inorganic vapors
Radiation Meter	-	Radiation
Cyanide Monotox	-	Cyanides
Oxygen Meter	-	Oxygen

2.4 MONITOR WELL CONSTRUCTION

Thirteen additional monitoring wells were installed at the Skinner site as part of the Phase II RI. The data from these wells was used to better define the ground water flow conditions and shallow bedrock hydrogeology, evaluate the hydraulic relationships between the surface water and ground water, better characterize ground water contamination, and to estimate the extent and rate of contaminant migration. The data gathered during the Phase I investigation showed that a vertical downward gradient existed at well cluster locations, and suggested that bedrock fracturing may be influencing flow. As a result, the deeper ground water may not discharge to the bordering streams, but instead flow beneath the streams. Because of these apparent conditions and the shallow depths to bedrock at some of the well locations, 10 of the 13 Phase II wells were screened in the fractured bedrock. The remaining 3 wells were screened in the unconsolidated aquifer. Monitor well locations are shown in Figure 2.3.

The monitoring wells were installed between February 20 and April 8, 1990. Installation techniques, sediment textures, sediment depths, depth of sediment sampling, and apparent VOC concentrations were recorded by a field geologist on a well/boring log sheet. Well/boring logs accompany this report as Appendix A. Table 2.4 indicates the screened intervals and sediment lithologies encountered in the existing wells at the Skinner site.

No three-well clusters were constructed during Phase II of the RI. Bedrock was encountered less than 20 feet below the water table or no water-bearing units were encountered between the upper well and the bedrock contact.

All drilling and well installation was supervised and documented by WWES personnel. All drilling equipment, including the drilling rigs, augers, tools, and sampling equipment was steam cleaned between each borehole. The split spoon samplers were washed with a soap and water solution then rinsed with municipal water between each sampling event.

2.4.1 Soil Sampling

Split-spoon soil samples were collected during the drilling of monitoring wells GW26, GW27, GW28, GW29, GW35, and GW38 for lithologic description and chemical analysis. The samples were field screened for VOC's with either an organic vapor analyzer (OVA) or one of two photoionization detectors including an organic vapor meter (OVM) and a Hnu. Only the deepest well at the well cluster locations was sampled by split spoon. Split spoon soil samples collected above the saturated zone during drilling were retained for chemical analysis. Soil samples from the monitor well borings are indicated with a GW, followed by the well number and a letter indicating the sampling interval. A summary of the sample intervals is included in Table 2.3.

2.4.2 Drilling Methods

The deep boreholes were advanced with 4 1/4-inch inner diameter hollow stem augers (HSA) until the augers reached the top of the bedrock. In instances where the bedrock was greater than 20 feet from the ground surface, the boreholes were enlarged with 6 1/4-inch HSA's. A 4-inch diameter black carbon steel casing was then secured in place with a cement-bentonite grout to the top of the bedrock. The casing was equipped with a drive shoe and was seated in competent bedrock. The drilling continued through the 4-inch casing, after the grout had set, using rotary wash drilling techniques and municipal water as a drilling fluid. The shallow boreholes were advanced using 4 1/4-inch HSA's with no additional enlargement.

2.4.3 Well Construction

All monitoring wells were constructed using 2-inch diameter, type 304 stainless steel casing and screens with flush joint threads. The screens were 5 feet in length with 0.010-inch continuous wire wound factory installed slots. Threaded stainless steel caps were installed at the bottom of the screen and at the top of the wells. All threaded joints, with the exception of the top well cap, were wrapped with Teflon tape. Prior to installation of each well, all well materials were steam cleaned to the satisfaction of WWES personnel. Appendix D contains monitor well construction diagrams for the Phase II monitor wells which were geophysically logged. Wells not presented were constructed in a similar fashion.

A sand pack of medium-grained silica sand was used as packing material around the screened intervals. The sand pack extended from the bottom of the open borehole to between two and four feet above the top of the well screens. Bentonite seals between two and four feet in thickness were placed on top of the sand pack zones using bentonite pellets. A bentonite/cement grout slurry was tremied from the bentonite seal to approximately one foot below the ground surface to seal the annular space between the well and the borehole. The same grouting procedure was used in the annular space between the stainless steel casing and the 4-inch black steel casing for completion of the deep wells.

A locking, steel, protective casing was cemented in the concrete apron at the land surface. The concrete apron was installed sloping away from the protective casing. Bumper posts were installed at well locations where there was potential for their being damaged. MW-38 was completed with a flush mounted, locking protective casing due to its location in a high traffic area.

2.5 BOREHOLE GEOPHYSICS

The primary purpose of borehole geophysical logging at the Skinner Site was to gather lithologic data: a secondary purpose was to determine the role bedrock fractures may have played in the flow of groundwater. Completed geophysical logs are located in Appendix D. Also included in Appendix D are lithologic interpretations and well construction details for the geophysically logged Phase II monitoring wells.

A suite of geophysical logs was obtained from nine wells, constructed during Phase II which penetrated the shallow bedrock. In addition, gamma logs were obtained from seven wells constructed by WESTON during Phase I. The borehole geophysical logger was used to measure properties of the formations. This instrument records the analog response of the probes on a continuous paper strip recorder. The logging suite included gamma, resistivity (both .25 and 2.5 normal), self potential (SP), single point resistance, caliper, and temperature logs. The gamma logs were used in conjunction with the resistivity and resistance logs to help delineate the lithology. The caliper and temperature logs were to be used to help understand the bedrock fractures.

The work plan for the Skinner Landfill RI/FS stated that a full suite of geophysical logs would be obtained from the uncased wells penetrating the shallow bedrock. The actual logging program deviated from the Work Plan and QAPP with respect to the caliper and temperature logs. The presence of swelling clays and washouts in the boreholes affected both the accuracy and retrievability of the caliper sonde. As a result a caliper log was attempted in only one borehole, GW38.

Temperature logs were obtained from only three wells, GW26, GW28 and GW38, because of recurring instrument problems in the temperature module.

2.5.1 INSTRUMENTATION

The borehole logs were collected with the Johnson-Keck model SR-3000 Borehole Geophysical Logging System. This system is composed of two separate units, the chain drive cable reel assembly and the SR-3000 control console with interfacing connections for the cable reel, console, and sensors. The system is mounted semi-permanently in a vehicle and powered by the vehicle's 12 volt D.C. battery. The logging probes or sensors are attached to the 1500-foot long cable using quick disconnect Marsh-Marine connectors capable of withstanding pressures of up to 20,000 psi. Analog recording is accomplished with two potentiometric servo chart recorders.

2.5.2 LOGGING PROCEDURES

The logs were collected by backing the vehicle as close as possible to the well, adjusting the instrument settings and lowering a sensor into the well with the aid of a pulley. As the down-hole log was run, in all instances except the temperature log, the instrument and recorder parameter sensitivities were adjusted for optimal data resolution. When the probe reached the bottom of the well an uphole log was run and used for interpretation. The temperature probe was calibrated at the WWES office in Grand Rapids, MI before the start-up of logging operations. Temperature logs were run first and were obtained during the downhole run to minimize mixing effects.

For the Johnson-Keck system there are four adjustable control console parameters common to all the logs: Chart Speed (CS), Logging Speed (LS), Module Sensitivity (MS), and Recorder Sensitivity (RS).

Chart Speed: Relates the rate of movement of the probe in feet/minute to the major divisions along the length of the chart paper. For the chart paper used, the CS was five.

Logging Speed: The actual rate of movement of the probe in feet/minute. For downhole logs the speed was set at 10 feet/minute and for greater resolution on the uphole logs a speed of 5 feet/minute was used.

Module Sensitivity: This parameter controls the sensitivity (amplitude or scale) of the recording. It was initially set on a high setting and adjusted while recording the downhole log to allow maximum curve amplitude on the chart paper. Used in conjunction with the Recorder Sensitivity, the two settings were multiplied to give the scale between major divisions on the chart paper. For example, module sensitivity of 1K and a recorder sensitivity of 0.2 are multiplied together to give a value of 200 between major divisions and a scale ranging from 0 to 2000 over the width of the chart paper.

Recorder Sensitivity: This parameter controls the gain at the chart recorder. This is always used together with the Module Sensitivity to determine the scale of the analog recording.

The sequence of borehole geophysical logs run in each suite was temperature, gamma, single point resistivity, self potential, and 0.25 and 2.5 normal resistivity. A brief discussion of procedures employed for each method is outlined below.

2.5.2.1 Temperature Log

The temperature probe was the first probe lowered into each borehole to avoid any potential mixing of borehole fluids as such mixing could mask temperature anomalies. The distance for the over-the-hole pulley to the ground surface was measured prior to placing the probe in the borehole. Sufficient cable was then routed out so that the distance from the base of the probe to the pulley was equal to the measured distance. A weight, approximately one foot in length, attached to the base of the probes to increase tension in the cable, prevented a temperature measurement in the bottom one foot of each boring.

2.5.2.2 Gamma Log

The gamma log was run after the temperature log. Measurements for the gamma log are made near the bottom of the probe and therefore the total depth corresponds closely with the measurement depth. The gamma log was run on both recorder channels: one channel had a higher recorder sensitivity for the purpose of obtaining better resolution in the unconsolidated soils which typically emit lower levels of gamma radiation than the shale-rich bedrock.

2.5.2.3 Resistivity Logs

The single point, 0.25 Normal (N) and 2.5 Normal (N) resistivity logs were run with an applied current of five milliamps through electrodes spaced approximately 75 feet in opposite directions from the borehole. The single point log was run independently while the other two resistivity logs were run simultaneously on separate recorder channels.

The resistivity probe is equipped with a bottom weight which prohibits the logging of the bottom 1.5 feet of the borehole. The surface datum was determined by measuring a distance of 15 feet from the probe to the probe/cable coupling and aligning the coupling with the ground surface. Thus, the probe provides a direct depth reference.

2.5.2.4 Self Potential Log

The self potential log was run with the same probe as the resistivity logs and a similar surface datum determination was made. The downhole portion of the log was run on a "set-up" setting which determines whether the polarity of the potential was positive or negative. The uphole log was run with positive polarity on the "normal" setting.

2.5.3 DECONTAMINATION

Decontamination procedures were followed at each borehole after logging was completed. Decontamination of equipment at upgradient wells involved the rinsing and wiping down of the sonde and cable with distilled water, as the sonde was raised to the surface. For wells suspected to be contaminated, the equipment was rinsed and wiped down and the sonde and cable later steam cleaned.

2.6 *IN SITU* HYDRAULIC CONDUCTIVITY MEASUREMENTS

In situ hydraulic conductivity testing was conducted at the Skinner site between March and May 1990 by WWES personnel. The purpose of this testing was to confirm the results of WESTON's work as presented in their Phase I report and to estimate the hydraulic conductivity of both the unconsolidated sediments and the shallow bedrock which underlie the Skinner site, as revealed by wells constructed during Phase II.

In situ hydraulic conductivity tests were performed on sixteen monitoring wells: wells screened in the both the unconsolidated sediments and in the shallow bedrock were tested.

2.6.1 GENERAL METHODS

The average hydraulic conductivity of a formation can be estimated by measuring the response of a monitoring well to a sudden change in water level. To perform an *in situ* hydraulic conductivity test, a known quantity of water is injected or removed nearly instantaneously into/from a monitoring well. The changing water level within the well is recorded as it returns to static condition. This is commonly referred to as a "slug" test.

An efficient means of achieving an instantaneous injection (or removal) of water is by applying a constant vacuum (or pressure) to the monitoring well until the water level in the well has stabilized. Release of the constant vacuum is equivalent to an instantaneous injection of water into the well (falling head test), while the release of a constant pressure is equivalent to an instantaneous removal of water from a well (rising head test).

As the water returns to the static level it is monitored using a pressure transducer connected to a Hermit data logger. The data logger is pre-programmed to collect water level measurements at logarithmic time intervals until the test is terminated by the operator.

2.6.2 HYDRAULIC CONDUCTIVITY CALCULATION

The recorded test data were transferred from the Hermit data logger to a personal computer via a menu-driven software package. Each test was saved as a unique file (e.g. MW03.PRN). The data files were then imported into a spreadsheet program (Lotus 1-2-3) which allowed the user to easily manipulate the data. The spreadsheet was used to convert the field data from minutes to seconds, to calculate the log value of the head, and to plot the data in the format required by the analysis method. These plots are shown in Appendix E.

The Bouwer and Rice (1976) method was used to analyze the recorded data and to calculate the hydraulic conductivity for each test performed. This method of analysis is not only applicable to unconfined aquifers but also to confined conditions if the water enters the aquifer through compression or leakage. The equations and assumptions of the Bouwer and Rice method are presented in Appendix E. Hydraulic conductivity calculation parameters used for each well are shown in Table 2.5.

The analysis of each slug test proceeded as follows: values of time and water level were selected from the straight-line portion of the plot of water level (logarithmic scale) versus time (arithmetic scale). For those plots which show a double or multiple straight line effect, the later straight line portion of the plot was chosen for use in the calculation. The later straight line is generally more indicative of flow within the undisturbed aquifer: the early straight line segment may be influenced by the sand pack around the screen (Bouwer, 1989). This effect becomes more pronounced with greater contrast between the formation and the sand pack hydraulic conductivities. The slope of the chosen line segment, the measured water level in the well and the well construction log provided the essential parameters in the Bouwer and Rice hydraulic conductivity calculation.

The hydraulic conductivities estimated by this method are typically less than those determined by actual pumping tests of the same aquifers (Dennis, 1987). Pumping test results as much as an order of magnitude higher have been observed; therefore the results of the slug tests are generally interpreted as being minimum hydraulic conductivity values for the aquifer. The use of minimum hydraulic conductivities will overestimate ground water, and possibly contaminant, travel times. The true hydraulic conductivity is likely to be greater than the slug test results. Given the possible range of hydraulic conductivities for similar kinds of aquifers, a low estimate that can be assumed to lie within a factor of two or three of the actual value is still very useful.

2.7 GROUND WATER SAMPLING

Of the thirteen new monitoring wells constructed at the Skinner Landfill as part of the Phase II RI, twelve were sampled. One of the newly installed wells, GW25, was dry at the designated time of sampling. These wells, in addition to 13 existing Phase I wells installed by WESTON in 1986 and two additional wells installed by the F.I.T. team in

1982, were sampled by WWES between April 23 and May 17, 1990 for a total of 27 sampling locations. This sampling was undertaken to further delineate the horizontal and vertical extent of ground water contamination. Ground water samples from the various monitoring wells were designated WW. For example, WW06 is the ground water sample from GW06.

The order of sampling proceeded from monitoring wells believed to have the least amount of contamination to those which had more contamination potential, generally from locations upgradient or at a distance from the buried lagoon to downgradient locations in close proximity to the buried lagoon. Prior to sampling, all newly constructed monitoring wells were developed until the pH and specific conductance of the purged water attained a near-constant value. This development practice is intended to provide for removal of all drilling fluids from the formation surrounding the well so that representative ground water samples may be obtained.

In conjunction with the 27 investigative samples, five duplicate, five field blank, ten trip blank and nine atmospheric samples were also collected. The sampled locations and designated analyses are shown in Table 2.6.

2.7.1 Ground Water Sampling Procedures

Before sampling, each monitoring well was purged of standing water. The water volume to be removed was determined using the following formula:

$$V = Tr^2(0.163)$$

Where:

V	=	static volume (gallons)
T	=	length of water column in the well (feet)
r	=	inside radius of the well (inches)
0.163	=	pi times a factor to convert cubic inches to gallons

The measured parameters and both the calculated and actual purge volumes were recorded in the field and are presented in the attached Well Sampling Field Record Form located in Appendix F. Discharge water was collected and measured to verify between three and five well volumes were removed prior to sample collection. If the monitoring well was completely dewatered during purging, the amount purged was reduced to two well volumes.

All purging and sampling utilized a clean Teflon bailer for each well. The ground water destined for analysis was immediately decanted into the appropriate sample containers. Purge water was retained and stored on-site in 55 gallon drums until the ground water analytical results could be reviewed. The drums were labelled with the water source location: if no contaminants are revealed during this investigation, the water will be discharged on site. If contaminants are detected, alternate disposal options will be selected. Waste disposal issues will be addressed in the Feasibility Study to be completed in 1991.

2.7.2 Decontamination Procedures

All ground water sampling equipment was decontaminated prior to use utilizing an Alconox wash solution, a municipal water rinse and a deionized water final rinse: alternatively, the equipment was steam cleaned. The equipment was laid out on clean plastic to air dry before use.

2.7.3 Field Measurements

Ground water samples were retained for field description: parameters recorded in field notebooks include pH, specific conductivity, temperature, color and noticeable odor. The measured specific conductivity was corrected for temperature. The specific conductivity, temperature and pH measurements are included in Table 2.7: each parameter was measured at least three times for greater accuracy. The pH and conductivity instruments were calibrated daily according to the standard operating procedures included in Appendix E of the QAPP.

2.7.4 Additional Samples

Blank sample preparation and collection frequency proceeded as follows:

Atmospheric Blank Samples - one atmospheric blank was prepared each day of sampling, typically at mid-day, by pouring deionized water into sample vials. These blanks will aid in determining the potential impact, if any, of airborne VOC compounds on the ground water samples.

Field Blank Samples - after the final distilled water rinse of the sampling equipment, deionized water was poured through the sampling equipment and then transferred to sample containers. One field blank was prepared for every 10 or fewer investigative samples. These blanks allowed the adequacy of decontamination procedures to be assessed.

Trip Blank Samples - trip blanks were prepared each day of sampling by pouring deionized water into sample vials. The trip blanks were prepared in the support area, away from any known sources of airborne contamination. The trip blanks were stored with and accompanied the sample containers into the field and to the laboratory. One trip blank accompanied each cooler containing volatile organic compound samples.

Duplicate Samples - the duplicate samples were collected at the same time as the investigative samples. One duplicate was collected for every 10 or fewer investigative samples.

Matrix Spike Samples - one matrix spike sample was collected from one sampling point at the same time as the investigative sample. Sampling frequency was one matrix spike for every 20 or fewer investigative samples.

The duplicate, matrix spike and field blank samples were preserved using the same procedures as the investigative samples. The preservation procedures followed those outlined in the QAPP.

2.8 DATA BASE DEVELOPMENT

Laboratory analytical data pertaining to investigations at the Skinner Landfill have been accumulating from 1976 until the present. These data have been presented in formats which vary by the investigating agency or environmental consulting firm. Additional analytical data was generated during the Phase II RI, presented in yet another format. WWES has compiled all the data, both current and historical, in the form of raw excerpts from the various source documents.

A common data base was developed that compiles all laboratory data generated for the Skinner Landfill since 1976. The data base has an Oracle format combining all previous formats, and the data may be retrieved from a Lotus spreadsheet in any desired format. Since data can be manipulated by virtually any field such as sample date, constituent or depth interval, this allows for an almost unlimited number of report formats. Besides ease of manipulation, the data base provides better data integrity and security and eliminates the possibility of errors due to transferring data from one form of media to another.

2.9 MONITORING WELL ABANDONMENT

A total of five existing monitoring wells were abandoned during the Phase II field work. The abandoned wells and the motivation for abandonment are as follows:

Monitoring Well Number	Justification for Abandonment
GW-8, GW-13	Monitoring wells were positioned in the vadose zone.
GW-21, GW-22	Monitoring wells were positioned in the active fill area and were inaccessible for ground water sampling purposes. (GW-22 contained elevated levels of selected constituents.)
GW-16	Monitoring well was positioned in or near the roadway. Ground water analyses from the well indicated that no elevated levels of analyzed constituents were detected.

As the monitor well casings could not be pulled using available equipment, the procedure used to abandon the wells consisted of cutting the casing off at grade, filling the casing and screen with a bentonite/cement slurry using a tremie pipe and capping the well. This procedure was approved by the U.S. EPA. The locations of these abandoned wells are shown on Figure 2.3.

2.10 RESIDENTIAL WELL SAMPLING

WWES developed a set of recommended criteria for selecting the residential wells most appropriate for sampling. These criteria include:

1. Close proximity to the landfill.

2. Well log record available.

3. Positioning downgradient from the landfill.

4. Completed below the ground water elevation measured along the site perimeter (in the creek valleys).

A review of residential well logs supplied by the Ohio Department of Natural Resources, Division of Water, revealed eleven off-site residential wells suitable for sampling, based upon the above criteria. Residents in close proximity to the site are typically connected to the municipal water supply.

Four residential wells, two off site and two on site, were sampled during the Phase II field work. Many of the wells previously identified as potential sampling points were abandoned or had become a non-primary water source when the residents were connected to the municipal water supply. Sampling took place on June 6, 1990. An appropriate amount of water was purged from each well before sampling. Off site sampling wells were located at 8754 Lousordville, West Chester and 8988 Cincinnati-Dayton road, West Chester with the first well screened in shale and the second screened in sandstone. One on-site well was located approximately 100 feet east of the WWES site trailers, and the other was located at Elsa Skinner's residence. Both wells are interpreted to be screened in the glacial deposits. Residential well locations are shown on Figure 2.3, (on-site wells), and Figure 2.5, (off-site wells).

2.11 GROUND WATER LEVEL MEASUREMENTS

Ground water levels were measured by means of the "chalked-steel tape" method. The steel tape was graduated such that the water level could be determined to an accuracy of +/- 0.01 foot. The static water level was measured, then confirmed with a second measurement. If the second measurement did not confirm the first, additional measurements were made until two identical elevation values were obtained. All measurements were recorded on appropriate forms or in field notebooks. If a measurement referenced a "holding point" other than the top of threads on the well casing, the reference point was clearly noted on the form and a diagram was used. All water levels used to predict the direction of ground water movement were completed within one day. Complete rounds of water levels were taken in 1990 on the following dates: May 6, May 15, and July 19. One additional round of water levels was taken on February 7, 1991 to investigate hydraulic characteristics during winter conditions. The measurements and calculated water elevations are presented in Table 2.8.

Water levels were measured after the wells had recovered from sampling. The May 15 measurement of GW06, however, does not appear to reflect the static water level. This measurement varied significantly from those previously measured, indicating that the well had not fully recovered from sampling. GW06 is screened in sediments of very low apparent permeability and full recovery may take several days. WESTON reported a similar situation in the Phase I Interim RI.

2.12 SITE SURVEY

Upon the completion of Phase II activities, the ground surface elevations and horizontal locations of all sampling points were measured. For the monitoring wells installed, a ground surface elevation and the elevation of the top of the well casing were obtained.

Elevations were determined with the use of a standard surveyor's level and stadia rod. A survey circuit was established beginning from a point of known elevation, proceeding to points of unknown elevation and returning to the point of beginning. An elevation survey was considered of acceptable accuracy if the beginning and final elevation were within +/- 0.03 feet. Survey notes were recorded on a standard form and included an accurate description of the point for which an elevation was determined. Ten percent (or a minimum of one per day) of all well elevations were measured in duplicate to determine the precision of this technique. The results of the site survey are presented in Table 2.9. The revised site survey was completed on June 14, 1990 and submitted to WWES on June 18, 1990.

SECTION 2

TABLES

Table 2.1
Skinner Landfill
Sample Label Key

	Location		Interval *		Type
BL	Buried Lagoon	A	First Sample Depth	AB	Atmospheric Blank
BP	Buried Pit	B	Second Sample Depth	DL	Dilution
GW	Monitor Well (Soil)	C	Third Sample Depth	DP	Duplicate
HA	Hand Auger	D	Fourth Sample Depth	FB	Field Blank
LS	Leachate Sediment	E	Fifth Sample Depth	MSD	Matrix Spike Duplicate
LW	Leachate Water			MS/MX	Matrix Spike
RW	Residential Well			RE	Reanalyzed Sample
SF	Surface Water				
SM	Stream/Pond Sediment				
WL	Waste Lagoon				
WW	Monitor Well (Water)				

* – soil sample intervals are indicated on Table 2.3 and Table 5.1

Table 2.2
Field Measurement Data
Skinner Landfill
Surface Water, Sediment and Leachate Samples

Location ID	Specific Conductivity (uhmos/cm) A	B	C	pH Measured (Std. Units) A	B	C	Temperature (deg. C) A	B	C	Sediment HNu/OVA/ OVM (ppm)
SF01	758	761	756	7.37	7.84	7.97	8	7.8	7.9	0
SF02	788	801	797	7.57	7.85	7.89	6.5	5.9	5.8	0
SF03	757	787	783	8.35	8.35	8.35	6.9	5.7	5.6	0
SF04	796	799	802	8.39	8.45	8.47	5.6	5.6	5.6	0
SF05	729	753	796	8.11	8.41	8.5	6.7	6.5	6.4	0
SF06	758	776	767	8.5	8.39	8.34	7.6	7.4	7.3	0
SF07	784	798	772	8.45	8.47	8.44	7.7	7.7	7.7	0
SF07DP	1763	1774	771	8.43	8.44	8.44	7.9	7.9	7.9	0
SF08	698	692	707	7.98	7.74	7.94	13	12.9	13	0
SF09	736	710	715	8.08	8.17	8.18	14.5	14	14.1	0
SF10	675	701	696	8.18	8.24	8.23	15.8	13.6	13.6	0
SF11	717	704	710	8.53	8.4	8.4	13.6	13.4	13.2	0
SF12	668	75	711	8.43	8.45	8.43	15.5	13.6	13.6	0
SF13	702	669	694	8.56	8.52	8.53	6.8	6	6	0
SF13DP	684	659	682	8.65	8.62	8.64	6.4	6.4	6.2	0
SF14	639	679	651	8.64	8.65	8.64	7.7	7.2	7.4	0
SF15	662	642	643	8.55	8.43	8.56	10.1	9.8	9.6	0
SF16	1158	1098	1019	7.81	7.9	7.91	10.8	10.7	10.3	0
SF17	868	867	915	7.37	7.41	7.48	8.4	8.4	8.3	0
SF18	641	663	640	7.38	7.21	7.25	9	8.7	8.9	0
SF19	585	582	632	7.6	7.53	7.42	8.8	8.7	8.6	0
SF20	968	959	946	8.28	8.45	8.44	4.4	4.2	4.3	0
SF21	945	959	958	8.72	8.22	8.24	7.1	6	5.7	0
SF21DP	968	959	946	8.28	8.45	8.44	4.4	4.2	4.3	0
SF22	906	858	831	7.32	8.15	8.17	5.9	6.4	6.3	0
SF23	919	888	873	8.04	8.08	8.14	7.4	7	7.9	0
SF24	942	916	903	8.3	8.41	8.26	7.1	7.2	7.4	0
SF25	1006	935	963	8.56	8.58	8.56	5.7	5.7	5.7	0
SF26	990	949	971	8.63	8.58	8.57	5.8	5.9	6	0
SF27	230	171	174	7.57	7.58	7.45	19	19.5	20.1	0
SF28	160	205	167	7.17	7.14	7.09	23.5	20.5	20	0
SF29	181	198	nd	7.21	7.42	7.07	26	21.6	22.9	0
SF30	260	325	232	9.34	9.33	9.27	11.5	11.5	11.6	1
SF31	228	203	227	9.44	9.42	9.46	12.5	12.1	12.3	11.4
SF31DP	231	227	227	9.41	9.45	9.41	12.3	12.1	12.2	11.4
SF32	233	225	226	9.04	8.87	8.77	11.9	12.2	12.8	1
SF33A	651	611	606	7.57	7.82	7.85	13.6	12.2	13	0
SF33B	633	616	615	7.79	7.86	7.84	11.3	11.8	12	0
SF34A	640	622	628	8.07	7.99	8.02	12.5	12.9	13.3	0
SF34B	644	598	613	8.16	8.11	8.05	13.2	12.7	12.9	0
SF35A	637	598	586	8.23	8.21	8.26	12.1	12.1	12.1	0
SF35B	579	598	593	8.16	8.15	8.15	11.8	12	11.9	0
SF36	705	691	717	8.84	8.85	8.85	6.3	6.4	6.4	-
SF37	912	925	904	8.13	8.07	8.09	6.3	6.1	6	-
LW01	2001	2025	2033	7.2	7.13	7.05	12.5	12.7	13	0
LW02	2435	2444	2448	7.3	7.39	7.49	9.7	10	10.2	0
LW03	732	752	740	7.11	7	7.1	11.1	11.7	11.9	0

nd = no data
A, B, C = replicate data
– = no corresponding sediment sample

Table 2.3

Skinner Landfill

Phase II Sampling

Soil Sample Intervals

Location	Sample Interval Depth (feet) A	B	C	D	E	F	G	H
BL-01	3.5 - 5.0	8.5 - 10.0	20.5 - 22.0	23.5 - 24.5	30.5 - 32.0	33.5 - 35.0	38.5 - 40.0	43.5 - 45.0
BL-02	4.0 - 5.5	8.5 - 10.0	13.5 - 15.0	18.5 - 21.5	23.5 - 25.0	27.5 - 29.0	29.0 - 30.5	-
BL-03	7.5 - 9.0	-	-	-	-	-	-	-
BP-01	1.0 - 2.5	-	-	-	-	-	-	-
BP-02	0.0 - 1.5	3.5 - 5.0	6.0 - 7.5	8.5 - 10.0	-	-	-	-
BP-03	0.0 - 2.0	-	-	-	-	-	-	-
GW-26	1.0 - 2.5	13.5 - 15.0	-	-	-	-	-	-
GW-27	1.0 - 2.5	23.5 - 25.0	28.5 - 30.0	33.5 - 35.0	38.5 - 40.0	43.5 - 45.0	-	-
GW-28	3.5 - 5.0	6.0 - 7.5	9.0 - 10.5	-	-	-	-	-
GW-29	1.0 - 2.5	3.5 - 5.0	-	-	-	-	-	-
GW-35	1.0 - 2.5	3.5 - 5.0	6.0 - 7.5	13.5 - 15.0	28.5 - 29.3	-	-	-
GW-38	1.0 - 2.5	3.5 - 5.0	6.0 - 7.5	13.5 - 15.0	-	-	-	-
HA-01	0.5 - 1.0	1.5 - 2.0	-	-	-	-	-	-
HA-02	0.5 - 1.0	1.5 - 2.0	-	-	-	-	-	-
HA-03	0.5 - 1.0	1.5 - 2.0	-	-	-	-	-	-
WL-01	19.5 - 21.5	21.5 - 25.5	-	-	-	-	-	-
WL-02	15.5 - 17.5	21.5 - 23.5	-	-	-	-	-	-
WL-03	17.0 - 19.0	19.0 - 21.0	21.0 - 23.0	27.0 - 29.0	29.0 - 31.0	-	-	-
WL-04	13.5 - 15.5	17.5 - 19.5	21.5 - 23.5	-	-	-	-	-
WL-05	23.0 - 25.0	27.0 - 29.0	43.0 - 45.0	-	-	-	-	-
WL-06	-	24.0 - 28.0	27.5 - 32.0	-	-	-	-	-
WL-07	19.0 - 21.0	21.0 - 23.0	25.0 - 27.0	27.0 - 29.0	31.0 - 33.0	-	-	-
WL-08	17.0 - 19.0	23.0 - 25.0	-	-	-	-	-	-
WL-09	25.0 - 27.0	31.0 - 33.0	-	-	-	-	-	-
WL-10	22.0 - 26.0	30.0 - 32.0	-	-	-	-	-	-
WL-11	22.0 - 24.0	26.0 - 28.0	30.0 - 32.0	-	-	-	-	-
WL-12	17.0 - 19.0	23.0 - 25.0	27.0 - 29.0	-	-	-	-	-
WL-13	33.0 - 35.0	38.0 - 40.0	-	-	-	-	-	-
WL-14	27.0 - 29.0	31.0 - 33.0	-	-	-	-	-	-
WL-15	22.0 - 24.0	36.0 - 38.0	-	-	-	-	-	-
WL-16	14.0 - 16.0	18.0 - 20.0	-	-	-	-	-	-

Table 2.4
Well Screen Intervals and Lithologies
Skinner Landfill

ID	Ground Elevation (ft)	Depth to Screen (ft)	Screen Elevation (ft)	Screen Length (ft)	Unit Screened
B05	731.09 *	12	719.09	3	Unconsolidated
B08	732.35 *	12	720.35	3	Unconsolidated
GW06	685.98	30.5	655.48	5	Unconsolidated
GW07	683.74	16	667.74	10	Unconsolidated
GW09	689.81	21	668.81	5	Bedrock
GW10	689.49	4	685.49	10	Unconsolidated
GW11	701.69	4.5	697.19	10	Straddle
GW12	699.72	4	695.72	10	Straddle
GW14	743.9	10	733.9	10	Unconsolidated
GW15	726.48	8	718.48	10	Straddle
GW17	747.97	34.5	713.47	5	Bedrock
GW18	748.12	17	731.12	10	Bedrock
GW19	731.21	22	709.21	10	Unconsolidated
GW20	734.38	42	692.38	10	Unconsolidated
GW23	767.82	5	762.82	5	Unconsolidated
GW24	694.12	18	676.12	5	Bedrock
GW25	694.36	8	686.36	5	Unconsolidated
GW26	697.27	34	663.27	5	Bedrock
GW27	734.23	62.5	671.73	5	Bedrock
GW28	686.35	23	663.35	5	Bedrock
GW29	720.31	23	697.31	5	Bedrock
GW30	676.62	21	655.62	5	Bedrock
GW31	675.79	11.8	663.99	5	Bedrock
GW32	671.12	39.1	632.02	5	Bedrock
GW33	670.54	7.8	662.74	5	Unconsolidated
GW35	669.88	36.9	632.98	5	Bedrock
GW36	669.84	8	661.84	5	Unconsolidated
GW38	684.5	43	641.5	5	Bedrock

* - Stickup Unknown, Ground Elevation Approximate.

Table 2.5
Hydraulic Conductivity Calculation Parameters
Skinner Landfill

Well ID	Le	Rc	Rw	Le/Rw	A	B	C	D	H	To	Yo	Tt	Yt	K	feet/day
GW-09	5	0.083	0.31	16.13			1.5	4.97	4.97	78.6	0.26	598.602	0.05	4.46E-06	3.86E-01
GW-10	10	0.083	0.31	32.26	2.57	0.42		17.67	13.17	61.006	0.89	386.004	0.11	5.27E-06	4.55E-01
GW-15	10	0.083	0.4	25.00			1.76	11.73	11.73	69.006	0.27	359.004	0.03	6.59E-06	5.69E-01
GW-15DP	10	0.083	0.4	25.00			1.76	11.73	11.73	94.602	0.53	569.604	0.03	5.26E-06	4.54E-01
GW-17	5	0.083	0.4	12.50			1.29	17.88	17.88	16.8	0.22	208.8	0.05	1.35E-05	1.17E+00
GW-18	10	0.083	0.4	25.00			1.63	8.34	8.34	0.6	2.62	29.004	0.43	5.13E-05	4.43E+00
GW-20	10	0.083	0.4	25.00	2.36	0.32		20	13.62	1.002	1.05	6.402	0.17	2.63E-04	2.27E+01
GW-24	5	0.083	0.4166	12.00			1.35	8.12	8.12	5.604	0.85	114.606	0.04	4.00E-05	3.46E+00
GW-26	5	0.083	0.161	31.06			2.05	11.72	11.72	1079.604	0.84	17399.6	0.06	3.45E-07	2.98E-02
GW-28	5	0.083	0.161	31.06			2.05	14.32	14.32	98.202	0.83	418.2	0.43	4.55E-06	3.93E-01
GW-30	5	0.083	0.161	31.06			2.05	17.24	17.24	239.604	0.33	569.604	0.09	9.00E-06	7.78E-01
GW-31	5	0.083	0.4166	12.00			1.35	6.88	6.88	5.604	1.64	74.604	0.06	6.54E-05	5.65E+00
GW-32	5	0.083	0.161	31.06			2.05	40.54	40.54	209.406	0.23	599.406	0.05	1.02E-05	8.79E-01
GW-33	5	0.083	0.4166	12.00	1.9	0.25		20.73	10.27	0.198	0.84	11.796	0.16	1.73E-04	1.50E+01
GW-35	5	0.083	0.161	31.06			2.05	38.8	38.8	73.404	3.22	1078.404	0.28	6.28E-06	5.43E-01
GW-36	5	0.083	0.4166	12.00			1.35	10.58	10.58	835.002	0.27	1555.002	0.16	1.11E-06	9.56E-02
GW-38	5	0.083	0.161	31.06			2.05	31.28	31.28	114.006	3.26	1199.004	0.12	7.63E-06	6.59E-01

Table 2.6
Skinner Landfill
Ground Water Sampling Locations
and Designated Chemical Analysis

ID	Organics	Inorganics	Additional Pesticides	VOA	Chloride/Sulfide/ BOD/TOC
WWB5	X	X	X	X	X
WWB5-FB	X	X	X	X	X
WWB8	X	X	X	X	X
WWB8-TB				X	
WWB8-AB				X	
WW06	X	X	X	X	X
WW06-TB				X	
WW06-AB				X	
WW07	X	X	X	X	X
WW09	X	X	X	X	X
WW10	X	X	X	X	X
WW10-DP	X	X	X	X	X
WW11-MS	X	X	X	X	X
WW11-AB				X	
WW11-TB				X	
WW12	X	X	X	X	X
WW12-DP	X	X	X	X	X
WW14	X	X	X	X	X
WW15	X	X	X	X	X
WW15-TB				X	
WW15-AB				X	
WW17	X	X	X	X	X
WW17-FB	X	X	X	X	X
WW18	X	X	X	X	X
WW19	X	X	X	X	X
WW20	X	X	X	X	X
WW20-TB				X	
WW20-AB				X	
WW23	X	X	X	X	X
WW24	X	X	X	X	X
WW26	X	X	X	X	X
WW27	X	X	X	X	X
WW28	X	X	X	X	X
WW28-TB				X	
WW28-AB				X	
WW29	X	X	X	X	X
WW29-TB				X	
WW29-AB				X	
WW30	X	X	X	X	X
WW30-FB	X	X	X	X	X

Table 2.6 (continued)
Skinner Landfill
Ground Water Sampling Locations
and Designated Chemical Analysis

ID	Organics	Inorganics	Additional Pesticides	VOA	Chloride/Sulfide/ BOD/TOC
WW30-TB				X	
WW30-AB				X	
WW31	X	X	X	X	X
WW31-DP	X	X	X	X	X
WW32	X	X	X	X	X
WW32-DP	X	X	X	X	X
WW33	X	X	X	X	X
WW33-DP	X	X	X	X	X
WW33-TB				X	
WW33-AB				X	
WW35-MS	X	X	X	X	X
WW35-TB				X	
WW36	X	X	X	X	X
WW36-FB	X	X	X	X	X
WW38	X	X	X	X	X
WW38-FB	X	X	X	X	X

Table 2.7
Field Measurement Data
Skinner Landfill
Ground Water Samples

Location ID	Specific Conductivity (uhmos/cm) A	B	C	D	pH Measured (Std. Units) A	B	C	D	Temparature (deg. C) A	B	C	D
B5	1359	1373	1382		7.07	7.09	7.09		12.7	12.5	12.5	
B8	653	652	650		8.11	8.03	8		11.6	11.7	11.7	
WW06	687	687	686		9.44	9.54	9.56		13.4	13.4	13.6	
WW07	904	918	922	921	7.15	7.29	7.32	7.39	11.5	11.6	11.6	11.7
WW09	991	989	985		7.12	7.15	7.17		13.7	13.9	14.2	
WW10	1588	1604	1617		7.44	7.47	7.48		15.3	15.4	15.5	
WW11	1875	1871	1869		7.1	7.06	7.05		13.1	13.1	13.2	
WW12	1933	1924	1955		7.06	6.99	6.99		12.7	12.8	12.7	
WW14	424	421	421		7.75	7.66	7.64		10.7	10.7	10.7	
WW15	1027	1017	1014	1016	6.87	6.71	6.72	6.7	12.3	12.5	12.6	12.8
WW17	1485	1482	1482		6.75	6.69	6.67		15.9	16	16	
WW18	1549	1551	1550		6.71	6.65	6.65		17.4	17.4	17.5	
WW19	896	896	897		7.19	7.19	7.2		13	13.1	13.1	
WW20	2291	2289	2299		6.73	6.72	6.75		13.3	13.4	13.4	
WW23	674	675	681	705	7.38	7.44	7.36	7.37	12.1	12.2	12.4	12.9
WW24	756	768	729		7.02	7.14	7.15		11.1	11.3	11.5	
WW26	1230	1231	1207		8.38	8.2	8.22		13.8	14	14.3	
WW27	971	967	965		7.25	7.25	7.24		13.2	13.3	13.4	
WW28	1869	1872	1813		8.33	8.35	8.32		11.5	11.5	11.4	
WW29	562	549	547		7.38	7.37	7.38		11	11.1	11.2	
WW30	945	951	957		7.39	7.39	7.37		11.2	11.2	11.2	
WW31	961	959	960		7.58	7.57	7.52		11	11.2	11.3	
WW32	2234	2244	2256		7.51	7.57	7.6		14.1	14.4	14.7	
WW33	889	903	899		7.24	7.32	7.32		13.7	14	14.4	
WW35	4694	4684	4761		7.43	7.53	7.54		13.8	14	14.1	
WW36	1396	1408	1419		7.3	7.23	7.19		11.5	12.1	12.8	
WW38	1098	1102	1107		7.85	7.85	7.84		12.8	12.8	12.8	

A, B, C = replicate data D = replicate data (optional)

Table 2.8
Ground Water Elevations
Skinner Landfill

Well ID	TOC	17-Apr-90 Measured	17-Apr-90 Elevation	18-Apr-90 Measured	18-Apr-90 Elevation	20-Apr-90 Measured	20-Apr-90 Elevation	08-May-90 Measured	08-May-90 Elevation	15-May-90 Measured	15-May-90 Elevation	19-Jul-90 Measured	19-Jul-90 Elevation	07-Feb-91 Measured	07-Feb-91 Elevation
GW06	687.98					11.69	676.29	12.57	675.41	35.75	652.23	OIL		4.11	683.87
GW07	687.74					8.76	678.98			5.39	682.35	9.13	678.61	Could not remove Cap	
GW09	693.21							23.95	669.26	24	669.21	24.05	669.16	23.55	669.66
GW10	690.29							2.09	688.2	2.49	687.8	2.73	687.56	Water in procasing	
GW11	706.09							5.89	700.2	6.15	699.94	7.94	698.15	4.99	701.1
GW12	703.95							5.23	698.72	5.51	698.44	6.66	697.29	Well destroyed	
GW14	746.9							11.24	735.66	12.54	734.36	14.05	732.85	12.68	734.22
GW15	729.58							6.25	723.33	8.18	721.4	12.48	717.1	7.26	722.32
GW17	750.67	25.1	725.57			25.29	725.38	23.97	726.7	24.21	726.46	26.72	723.95	23.35	727.32
GW18	750.42	21.99	728.43			22.22	728.2	20.75	729.67	20.86	729.56	25.97	724.45	20.3	730.12
GW19	734.21							21.2	713.01	20	714.21	23.83	710.38	21.47	712.74
GW20	737.88							41.59	696.29	41.45	696.43	40.72	697.16	40.84	697.04
GW23	769.82							4.16	765.66	4.45	765.37	10.05	759.77	3.6	766.22
GW24	696.12	17.52	678.6	17.56	678.56	17.57	678.55	16.34	679.78	16.88	679.24	18.09	678.03	15.84	680.28
GW25	696.36					DRY		DRY		DRY		Approx. 4" in screen		DRY	
GW26	699.27	29.49	669.78	29.545	669.725	29.56	669.71	29.27	670	29.34	669.93	29.88	669.39	29.13	670.14
GW27	736.73	67.14	669.59	67.485	669.245	67.15	669.58	66.97	669.76	66.91	669.82	67.5	669.23	66.73	670
GW28	688.25			15.9	672.35	15.95	672.3	15.62	672.63	15.58	672.67	16.07	672.18	14.75	673.5
GW29	722.11			25.36	696.75	26.52	695.59	26	696.11	26.04	696.07	27.42	694.69	25.94	696.17
GW30	678.62	10.95	667.67	11.155	667.465	10.95	667.67	10.66	667.96	10.69	667.93	10.46	668.16	10.01	668.61
GW31	677.59					11.68	665.91	11.57	666.02	11.49	666.1	11.11	666.48	10.53	667.06
GW32	673.02	5.54	667.48	5.59	667.43	5.58	667.44	5.51	667.51	5.46	667.56	6.13	666.89	5.18	667.84
GW33	672.74					4.83	667.91	4.68	668.06	4.73	668.01	5.19	667.55	4.62	668.12
GW35	671.98	4.39	667.59	4.45	667.53	4.45	667.53	4.44	667.54	4.4	667.58	4.65	667.33	4.12	667.86
GW36	671.84					4.84	667	4.64	667.2	4.71	667.13	5.28	666.56	4.47	667.37
GW38	684.5	15.69	668.81	15.785	668.715	15.75	668.75			15.59	668.91	15.57	668.93	14.89	669.61
BO06	731.09							11.46	719.63	8.36	722.73	11.74	719.35	9.82	721.27
BO08	732.35							9.36	722.99	10.88	721.47	12.33	720.02	11.78	720.57

Table 2.9
Skinner Landfill
Survey Data

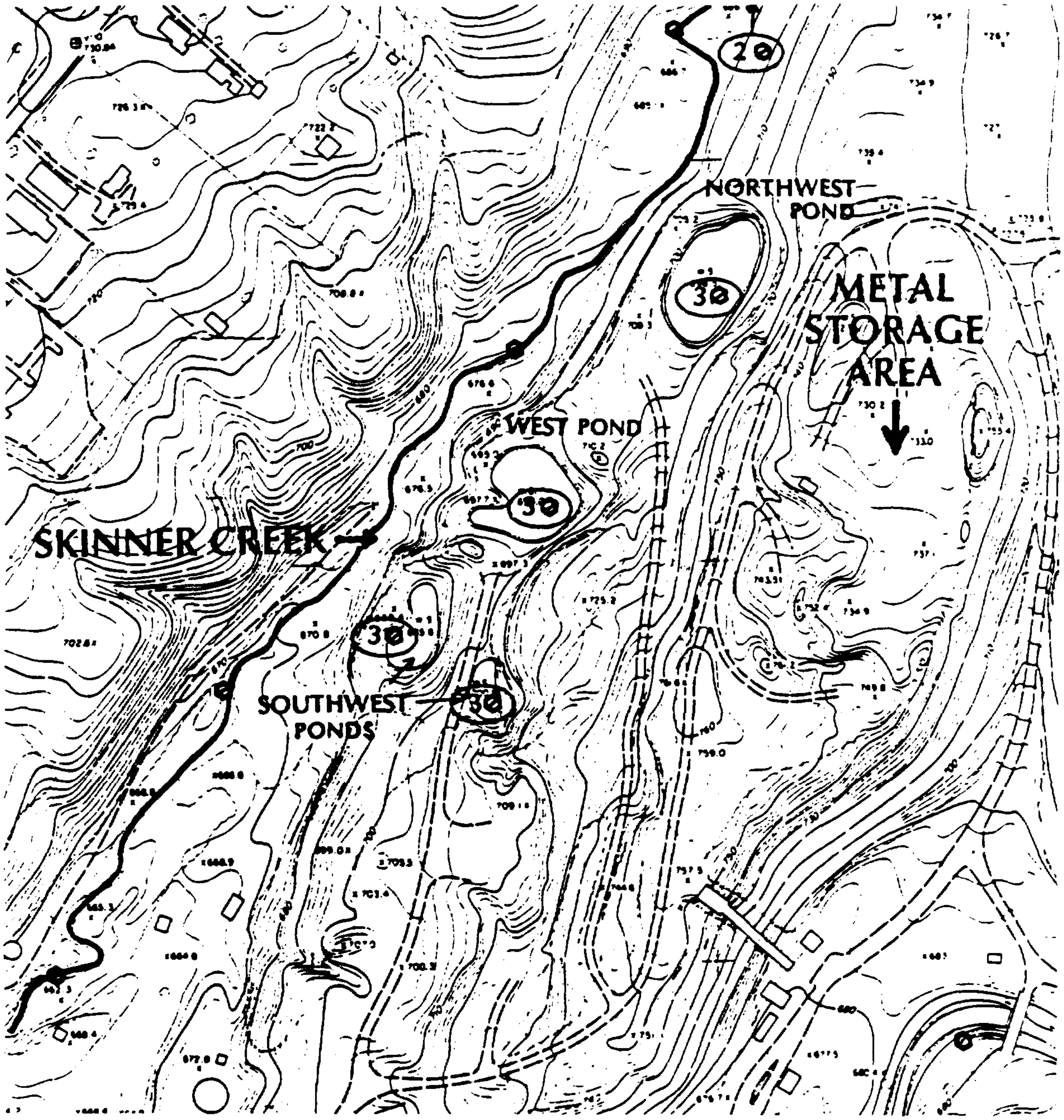
Point Number	Location ID	N Coord	E Coord	Elevation	Point Number	Location ID	N Coord	E Coord	Elevation
326	B05	8746.37	11077.18	731.09	272	GW30	8337.76	10794.44	678.62
322	B08	8923.54	11014.49	732.35	273	GW31	8336.19	10789.49	677.59
327	BL01	8678.58	11144.85	735	343	GW32	8779.22	9990.89	673.02
323	BL02	8798.78	11046.99	732.48	342	GW33	8765.47	9983.35	672.74
321	BL03	8956.05	11017.85	732.5	345	GW35	8851.21	9849.08	671.98
347	BP01	8425.33	9782.46	664.9	344	GW36	8846.44	9845.14	671.84
262	BP02	8397.97	9744.81	666.11	275	GW38	8491.11	10877.43	684.5
348	BP03	8462.39	9779.33	665	301	HA-01	9402.68	11185.29	749
276	GW06	8491.58	10867.63	687.98	302	HA-02	9396.12	11271.09	749.4
277	GW07	8483.04	10864.34	687.74	303	HA-02	9401.15	11355.38	749.1
287	GW09	8672.79	11290.13	693.21	279	LS-01	8455.33	11312.3	681.15
288	GW10	8670.6	11287.18	690.29	285	LS-02	8760.19	11537.11	687.2
293	GW11	8877.5	11484.71	706.09	341	LS-03	9063.93	10101.58	671.1
292	GW12	8878.89	11591.87	703.95	294	SD/SM 16	8897.88	11719.99	700.6
332	GW14	9021.96	10567.21	746.9	297	SD/SM 17	9215.83	11878.12	720.7
300	GW15	9409.53	10869.25	729.58	296	SD/SM 18	9225.54	11872.25	720.9
304	GW17	9228.5	11088.71	750.67	298	SD/SM 19	9333.96	11878.45	728.2
305	GW18	9223.78	11095.58	750.42	268	SD/SM 20	8174.16	9029.28	650
324	GW19	8783.3	11035.42	734.21	346	SD/SM 21	8458.16	9632.32	661.1
328	GW20	8733.38	11212.65	737.88	340	SD/SM 22	9020.5	10076.53	670.9
330	GW23	9874.1	11811.35	769.82	335	SD/SM 23	9314.54	10298.5	676.5
282	GW24	8502.79	11390.9	696.12	337	SD/SM 25	9643.27	10465.85	684.3
283	GW25	8496.79	11391.47	696.36	338	SD/SM 26	9756.72	10511.14	686.5
299	GW26	8831.14	10872.6	699.27	284	SF36	8680.85	11371.09	681.6
329	GW27	8738.05	11203.57	736.73	334	SF37	9224.21	10187.28	673.9
278	GW28	8358.57	11089.49	688.25	271	SF/SM 01	7872.01	8489.93	639.5
333	GW29	9211.47	10495.75	722.11	270	SF/SM 02	7838.87	8665.73	641.4

Table 2.9 (continued)
Skinner Landfill
Survey Data

Point Number	Location ID	N Coord	E Coord	Elevation	Point Number	Location ID	N Coord	E Coord	Elevation
267	SF/SM 04	7882.6	9161.92	647.4	316	WL02	9064.52	11173.19	749.8
266	SF/SM 05	7915.8	9808.62	655	317	WL03	9009.11	11232.67	750.8
265	SF/SM 06	7997.33	10049.65	657.55	318	WL04	9038.05	11300.84	747.3
264	SF/SM 07	8111.74	10327.83	661.3	307	WL05	8949.05	11119.26	757.3
263	SF/SM 08	8181.69	10639.51	665.41	311	WL06	8960.48	11175.71	753.4
274	SF/SM 09	8433.69	10812.92	669.4	312	WL07	8961.64	11223.43	751.4
281	SF/SM 10	8322.48	11253.64	675.9	319	WL08	8960.16	11275.2	749.3
286	SF/SM 11	8804.62	11667.86	685.8	308	WL09	8891.43	11120.94	760.8
289	SF/SM 12	8874.56	11867.83	687.5	310	WL10	8908.94	11177.78	756
290	SF/SM 13	8833.36	12091.35	691.7	313	WL11	8913.86	11224.15	753.3
291	SF/SM 14	8853.62	12345.95	694.7	320	WL12	8916.74	11260.7	750.5
336	SF/SM 24	9454.49	10411.29	680.3	325	WL13	8733.53	11045.65	729.6
331	DIVING POND	9324.9	10448	699.02	309	WL14	8835.67	11175.87	762.3
339	TRILOBITE POND	8919.3	10104.8	688.7	314	WL15	8870.52	11224.73	754.5
306	WL01	9010.45	11131.07	753.9	315	WL16	9150.85	11140.55	752.7

SECTION 2

FIGURES



N

0 100 200 400

Scale in Feet

(Adapted from figure 8, WWES work plan)

⊘ Proposed Sampling Locations

Figure 2.1

Proposed Sediment and Surface Water Sampling Locations with Pre-Investigation Topography

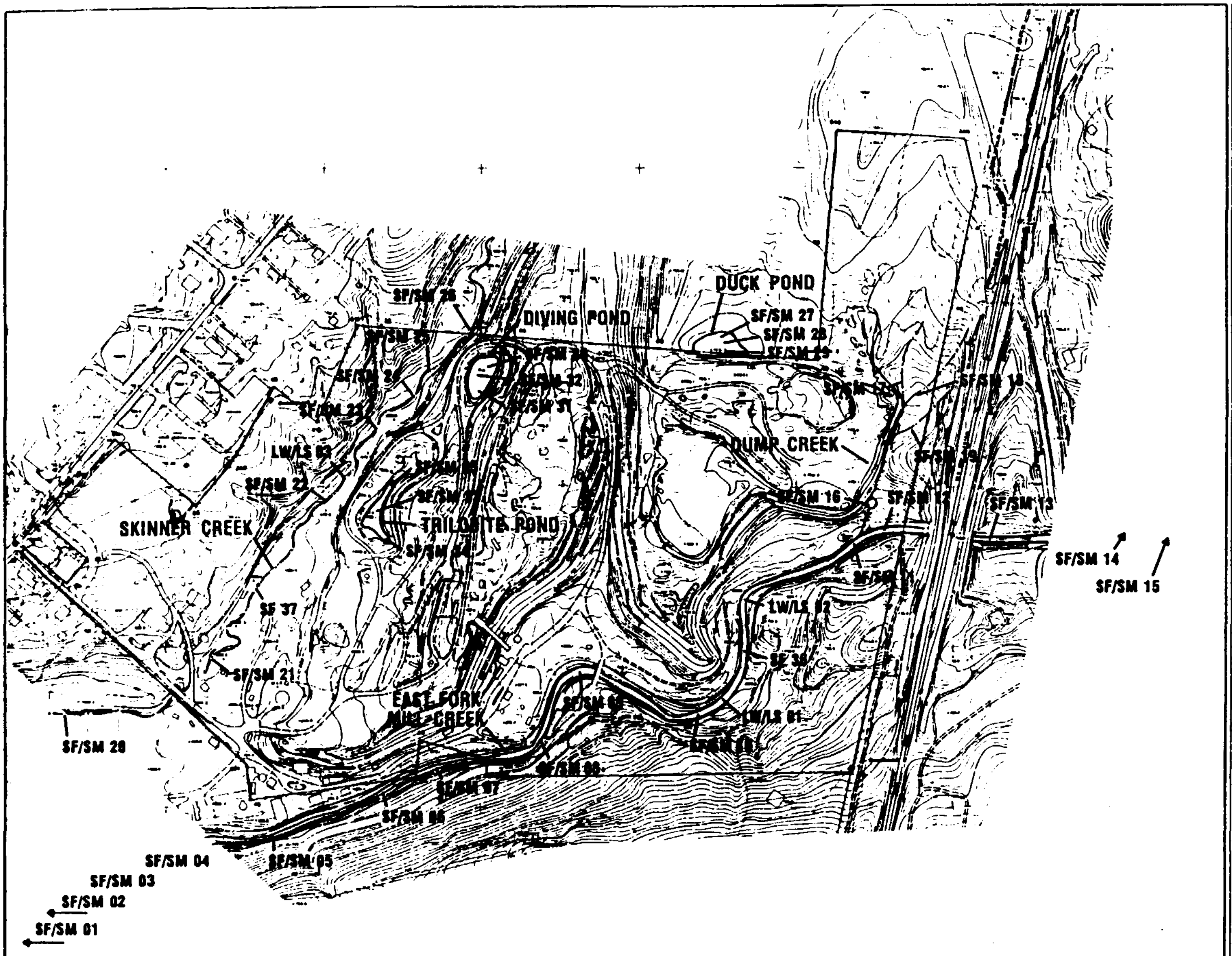
Skinner Landfill

West Chester, Ohio

February, 1991

04003.14

WW Engineering & Science



LEGEND

SF 37 Surface Water Sample

SF/SM 01 Surface Water and Sediment Sample

LW/LS 01 Leachate Water and Sediment Sample

Disappearance Point of Stream

Spring/Appearance Point of Stream

N

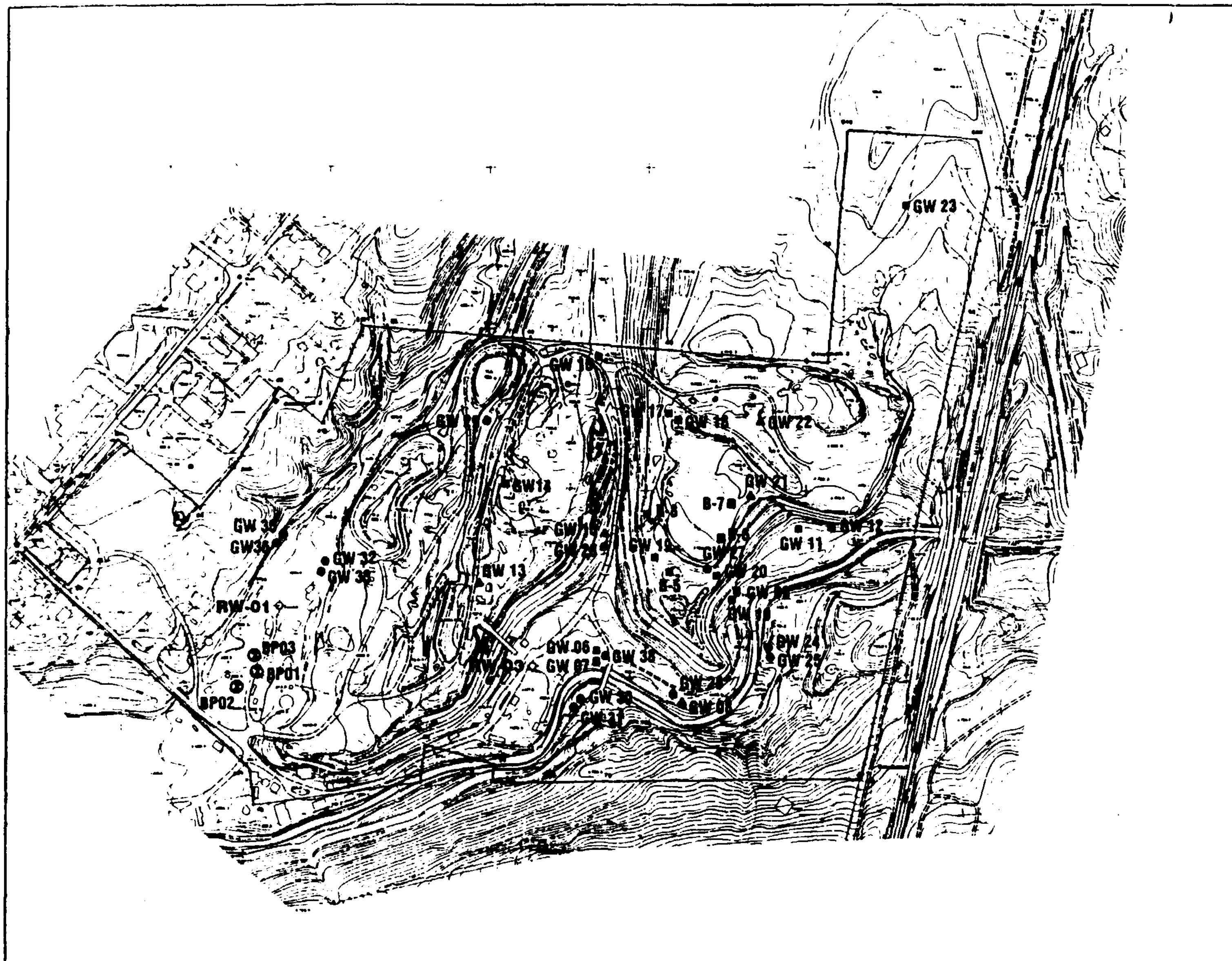
0 150 300 600
Scale in Feet

Figure 2.2, 5.8

SURFACE WATER, SEDIMENT AND LEACHATE SAMPLING LOCATIONS

Skinner Landfill
West Chester, Ohio

February, 1991 04003 14



LEGEND

- ● Monitoring Well (Phase II)
- ■ Monitoring Well (pre-Phase II)
- ▲ Abandoned Monitoring Well
- ⊕ Buried Pit Boring
- ◇ Residential Well

Note: Former Locations of B-6 and B-7 are approximate

N

0 150 300 600

Scale in Feet

Figure 2.3, 5.7

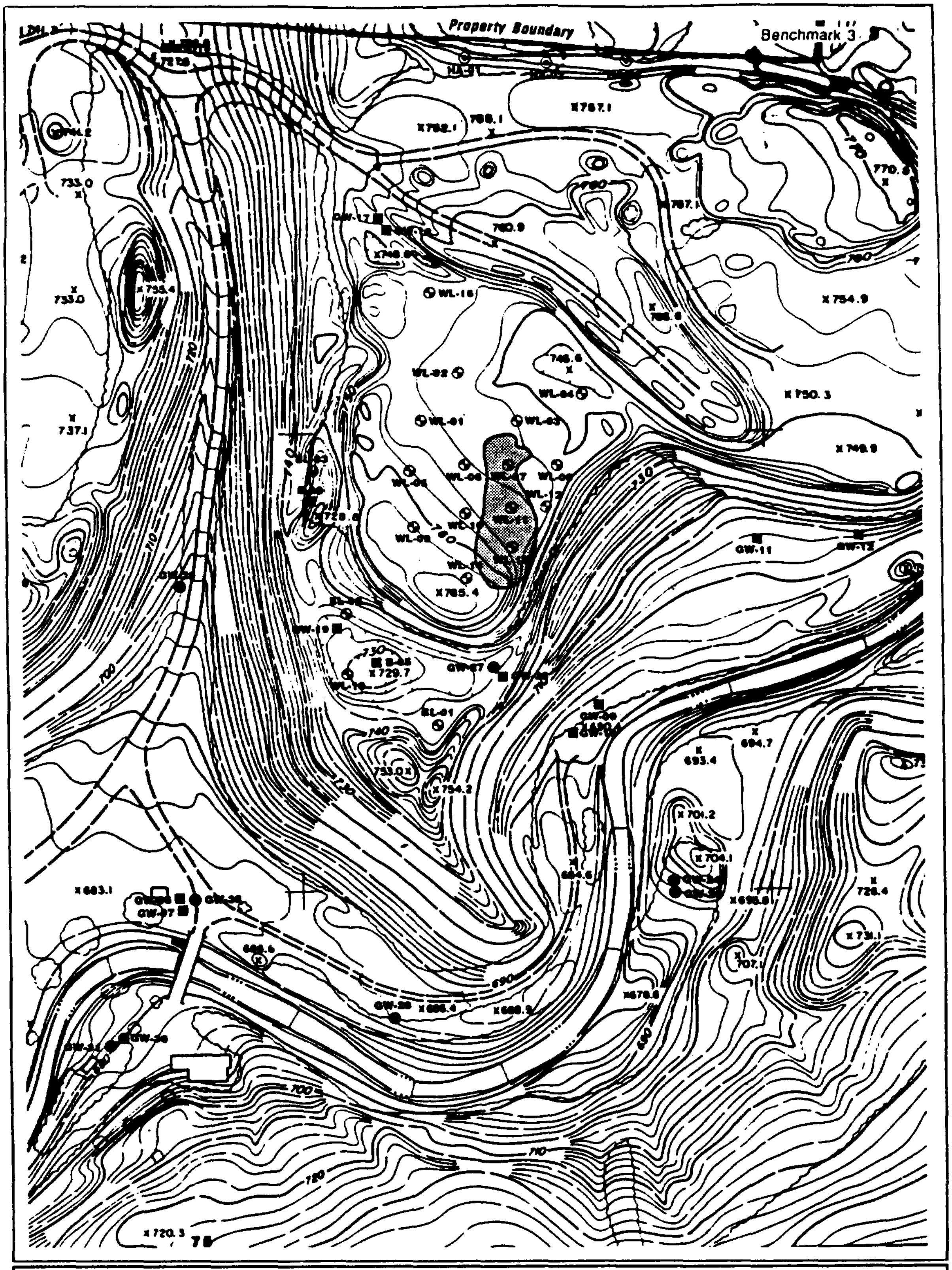
Site Map with Monitoring Well, Residential Well and Buried Pit Boring Locations

Skinner Landfill

West Chester, Ohio

February, 1991

04003.14



LEGEND

- ■ Pre Phase II Wells
- ◎ Hand Auger
- ● Soil Boring/Monitor Well
- ⊕ Soil Boring
- Approximate Area of Lagoon from Aerial Photos

N

0 50 100 200

Scale in Feet

Figure 2.4, 5.6

WASTE LAGOON AREA

Monitor Well and Soil Boring Location Map

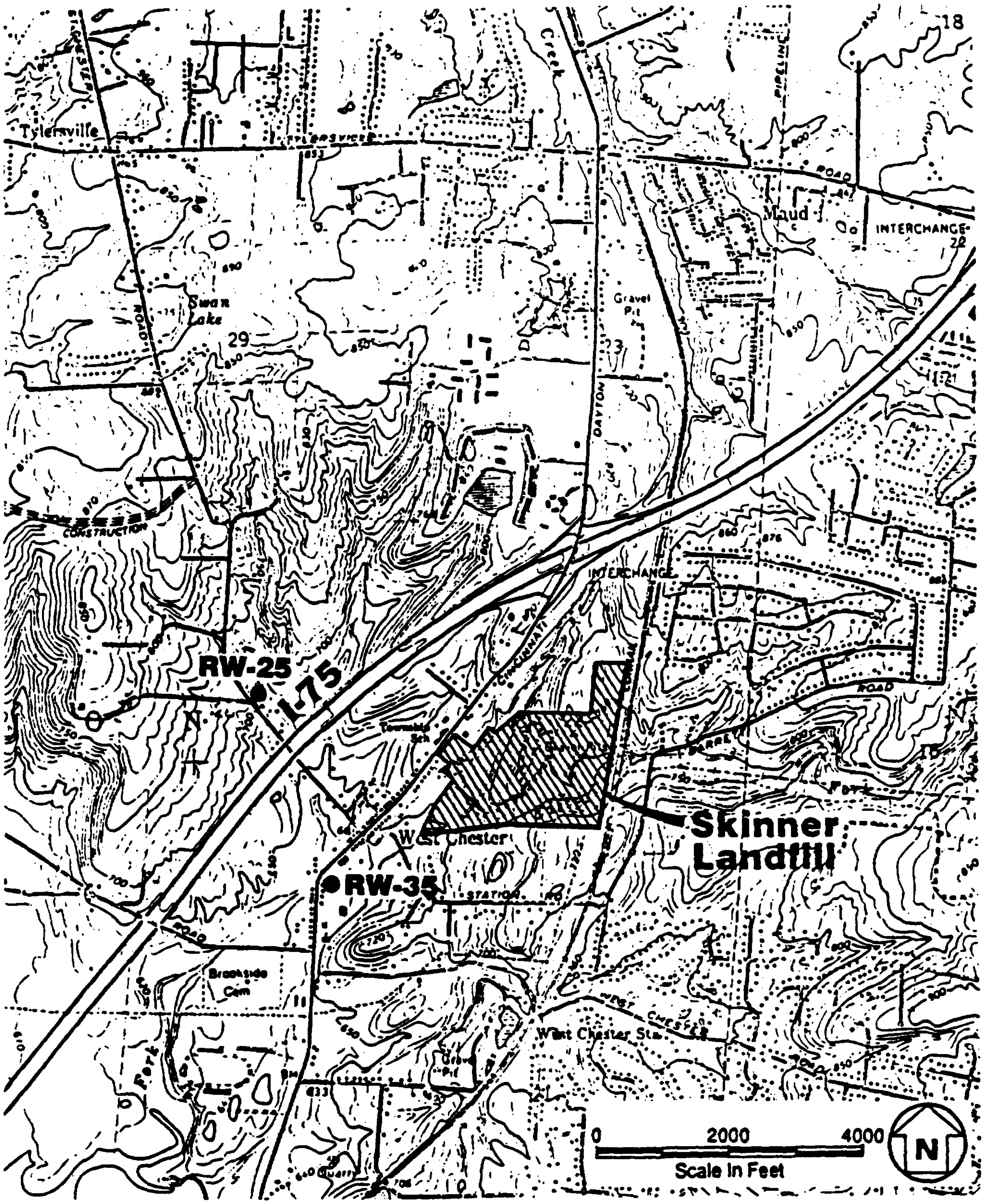
Skinner Landfill

West Chester, Ohio

WW Engineering & Science

November, 1990

04003.14



Map copied in part from USGS Glendale Quadrangle (7.5 minute)

● Residential Well

Figure 2.5

Off Site Monitor Well Location Map

Skinner Landfill

West Chester, Ohio

February, 1991

04003.14

WW Engineering & Science

3.0 GEOLOGIC SETTING

This section describes the regional geology of the Cincinnati area and the site geology of the Skinner Landfill. It was prepared using literature sources, previous studies and data generated during this investigation.

3.1 REGIONAL GEOLOGIC SETTING

The geologic formations which occur at the surface in Butler and Hamilton Counties are of sedimentary origin and range in age from late Ordovician to Quaternary. They fall into two general classes: (1) the consolidated, stratified sedimentary rocks of Ordovician age and (2) the unconsolidated deposits, which include the glacial deposits of Pleistocene age (Bernhagen, 1947).

The Skinner Landfill lies near the middle of the Cincinnati Arch. The bedrock units near the site have a dip of one foot per mile to the west (Thelen, 1980) and consist of Late Ordovician age thin-bedded calcareous shales and blue-gray limestones, part of what is known as the Cincinnatian Series. The maximum thickness of this series is between 800 and 1000 feet, of which approximately two-thirds is shale and one-third limestone. Locally, the amount of limestone increases upward in the geologic section (Speiker, 1961).

Nearly all the shale beds are laminated and often interfinger with either the edges or the surfaces of the interbedded limestones. The carbonate sediment was lithified before the muds, with the lamination in the shales bending to conform to the shape of the limestone layers. The limestone beds served as rigid limits during mud compaction (Weiss et al, 1965).

The shales are composed of medium to fine-grained silts with less than 3% sand. No variation in grain size is present either laterally or vertically within the series as a whole, but size variation sometimes occurs from the middle to the boundaries of individual mudrock beds. Courser sizes tend to occur near the contacts with adjacent limestone beds (Weiss et al, 1965).

Prior to the Pleistocene glaciation, the Cincinnati region was a broad upland plain cut by valleys whose floors were 350-500 feet below the upland surface and 100-250 feet below the floors of the present valleys. The valley walls were steep and rugged, and the floors were narrow gorges. Most of the rivers were still cutting downward, and no extensive flood plains had been developed. Small streams cut sharp tributary canyons in the valley walls (Klaer, 1948).

The materials that filled the ancient buried valleys consist of sand, gravel and clay deposited during the latest glacial epoch. The conditions under which the various valley fill sediments were deposited were not uniform throughout the area at any one time. While sand and gravel outwash material were being deposited in one locality, a short distance away fine sediments would be settling in the quiet waters of a lake. The ice undoubtedly advanced and retreated short distances many times, each movement resulting a change in the texture of sediments being deposited. Sediment textures vary widely, both horizontally and vertically.

Many of the sand and gravel beds appear to have greater continuity in directions parallel to the axes of the valleys and could represent channel deposits of former streams. Comparisons made by Klaer (1948) of many well logs showed that it is extremely difficult and often impossible to trace a particular sand or clay bed from one well to another well less than a quarter of a mile away.

The sands and gravels derived from the ice sheet are generally more angular than those transported solely by streams. In relatively small channels that were choked with glacial debris, the streams split into many smaller channels, and probably meandered back and forth, similar to the braided streams flowing from melting glaciers at the present time.

The glacial epoch ended with the recession of the Wisconsin age ice sheet. Present surface drainage patterns have followed the pre-glacial valleys in some places and in others have followed the courses that were scoured during glaciation. Streams have since eroded much material of glacial origin and have partly re-excavated many of the buried valleys. In many places the valley walls are steep and dissected by streams (Klaer, 1948).

3.2 PHYSIOGRAPHY

The physiography of the Skinner Landfill can be characterized as two parallel hills oriented in a north-south direction bordered on the west and south by small creeks and on the northwest by uplands. Elevations range from approximately 645 feet above mean sea level (MSL) in the southwest to 794 feet (MSL) in the north. A prominent physiographic feature of the area is the East Fork of Mill Creek which flows toward the southwest and forms the eastern and southern boundaries of the site. The active landfilling area produces a dominant bluff overlooking this creek in the northern portion of the site. These and other features are shown on Figure 3.1, the topographic map prepared from the site survey. The topography depicted represents site conditions as of April 25, 1985, with updated ground control measured in June 1990.

3.3 SITE GEOLOGIC CONDITIONS

As part of the Phase II RI at the Skinner Landfill, 35 soil borings were completed. The lithologies and depths encountered are recorded on the well and boring logs contained in Appendix A of this report. Those borings labeled GW were completed as monitoring wells, those labeled BL or WL were located near and within the former waste lagoon area, while those labeled BP were located near the former buried pit. The locations of the Phase II borings which were converted to monitoring wells, the pre-existing wells, and the buried pit (BP) borings are shown in Figure 3.2. The borings and wells located in the waste lagoon area are shown in Figure 3.3.

The geological conditions present beneath the Skinner Landfill site are consistent with the regional geologic setting. The general geologic setting of the site consists of steep walled bedrock valleys comprised of Ordovician carbonates and shale. These bedrock valleys are filled with unconsolidated sand, gravel, silt, and clay sediments. These mixed-textural sediments are complexly interbedded and gradational. The lithologic information provided by the Phase II borings was combined with the elevation survey and previous lithologic logs to produce a series of cross sections presented as Figures 3.4 through 3.11. Pre-Phase II lithologic information was included when accurate locations and elevations could be determined and when lithologic descriptions were consistent with the Phase II descriptions. The cross section traces are shown on Figures 3.2 and 3.3.

3.3.1 INTERPRETATION OF BOREHOLE GEOPHYSICS

A suite of geophysical logs was obtained from nine wells, constructed during Phase II, which penetrated the shallow bedrock. In addition, gamma logs were obtained from seven wells constructed by WESTON during Phase I. These logs are included as Appendix D of this report. Also included in this Appendix are lithologic interpretations and well construction details for the new bedrock wells.

3.3.1.1 Phase I Wells

Gamma logs were run on the following existing wells: GW-06, GW-09, GW-14, GW-15, GW-17, GW-19 and GW-20. Wells not logged were either inaccessible or abandoned. This set of logs was run to confirm the lithologies and construction details presented by WESTON in their Interim Phase I RI.

Bedrock descriptions reported on WESTON's lithologic logs do not differentiate between shale and limestone in the bedrock; typical descriptions indicate interbedded gray, fossiliferous limestone and gray shale. These descriptions are consistent with the bedrock examined by WWES. The gamma logs indicate grout and benseal intervals which are generally consistent with those reported. Slight shifts in depth are not relevant. Top of bedrock elevations may be shifted slightly as contacts between shale and a clayey till are sometimes difficult to distinguish. Total depths may vary from those reported due to well silting.

3.3.1.2 Phase II Wells

A suite of logs was run on Phase II wells installed by WWES, in accordance with the methods described in Section 2.5. The logged wells include GW-24, GW-26, GW-27, GW-28, GW30, GW-32, GW-35 and GW-38. Shallow bedrock electrical logs were obtained for the uncased portions of the boreholes, below the water table.

The lithological interpretation of the geophysical logging suites is presented in Appendix D. The unconsolidated portion of these lithologic columns was inferred from the field descriptions of split spoon samples while the bedrock portions are interpreted from the geophysical logs. The indicated bedrock stratigraphy is conservative in interpretation. Thicker layers may not be exclusively limestone or shale and could contain thin beds which the geophysics could not differentiate. Also included on these figures are well construction details.

No significant gamma response differences are clearly associated with what has been described as clays vs. gravels on the lithologic logs. The descriptions recorded on the lithologic logs were based on actual split spoon samples and are considered a more accurate interpretation of the unconsolidated sediments than the gamma response. The gamma response in the unconsolidated section is typical of a clayey or silty sequence, the zones described as gravels and sands on the lithologic logs may contain enough silt or clay to give the response observed. This gamma response is typical of tills or morainal deposits where the sediment is a gross mixture of varying sediment textures. Most of the logs indicate a sharp break between the sediments of glacial origin and the underlying bedrock, making a weathered bedrock zone unlikely. The geophysical logs are considered more accurate in delineating bedrock lithology than the boring logs as bedrock sample cores were not taken.

3.3.2 BEDROCK GEOLOGY

3.3.2.1 Bedrock Fractures

The valley walls of East Fork Mill Creek are steep in places where erosion has exposed bedrock on the hill sides. In the central and southern portion of the site, the creek flows on limestone layers and provides an excellent opportunity for the observation and description of bedrock fracture orientation. Visual inspection of limestone exposed along the East Fork of Mill Creek indicates a prominent fracture system in the limestone layers oriented approximately north-south with a secondary, less pronounced, less continuous fracture system occurring at approximately a 90 degree angle to the first. Fracture spacing varies between approximately four and fourteen inches in both sets of fractures. This same fracture orientation and spacing is revealed in the bedrock around the Trilobite Pond occurring at a higher elevation on the western side of the site. The fracture system observed in the limestone units on the east and west flanks of the site is probably consistent across the entire site.

The caliper and temperature geophysical logs were chosen to help define the subsurface fracture system. The caliper log was not run due to the probability that the sonde would be lost; however, the temperature log was run on several wells. Anomalies in the ground water temperature were interpreted to be related to flow including some temperature anomalies related to bedding planes. The origin of other anomalies were not determined, but were possibly due to fracture flow. The temperature logs were of little value without the caliper logs in distinguishing fractures from bedding planes. The discussion of the temperature logs relating to ground water flow is continued in Section 4.4.3.3.

3.3.2.2 Bedrock Lithology

Lithologic samples of the bedrock were not collected during the construction of the deep borings. The lithologies indicated on the logs were inferred from drilling rates and from cuttings gleaned from the drilling water. The borehole bedrock lithology is best defined by the geophysics as no bedrock cores were taken during Phase II drilling. Visual inspection of outcrops on East Fork Mill Creek reveal lithologies and bed thickness corresponding to those discussed in Section 3.1 -- thin fossiliferous limestone with blue-gray shale interbeds. The thinly bedded limestones range in thickness from less than 1 inch to greater than 12 inches and were observed to thin and pinch out in creek bed exposures. Thelen (1980) observed that the limestone layers are not necessarily continuous and may pinch in and out.

Some variation in bedrock lithology was noted by WESTON during the construction of GW-17 and GW-18, located to the north of the buried waste lagoon. The lithologic logs describe "interbedded gray shale to pebbly shale and gray fossiliferous limestone." While this lithology was not observed by WWES on the Skinner site, the Phase II drilling did not include borings into bedrock in this region. Thus, the descriptions must be taken as valid and may represent a weathered or fractured zone. Permeabilities in these two wells were approximately one order of magnitude greater than other bedrock wells. This will be discussed further in Section 4.0.

3.3.2.3 Bedrock Elevation

Seven of the Phase II soil borings were completed in the bedrock, providing a greater concentration of bedrock elevation points and allowing the preparation of a more accurate bedrock surface elevation map. This map also utilized data from WESTON's report, including the soil boring and geophysics information. In addition, elevation contours were drawn to coincide with visible outcrops along the East Fork of Mill Creek, as described previously. This bedrock elevation contour map is presented as Figure 3.12.

The bedrock surface reflects the pre-glacial erosional surface described in the literature, with some superimposed glacial erosion. The East Fork of Mill Creek has partially re-excavated the former valley, and in the central and southern portion of the site, has begun to erode the bedrock. Skinner Creek, however, while located near to the buried valley wall, flows only on the post-glacial unconsolidated sediments.

3.3.3 UNCONSOLIDATED SEDIMENTS

Sharp changes in lithology of unconsolidated sediments are uncommon at the Skinner site. The sediments do not fall neatly into categories but exhibit a progressive gradation, both horizontally and vertically, from clay-rich to gravel-rich strata, with each recovered sample containing a textural mixture. Gravel and sand rich zones may best be interpreted to be high energy outwash or stream deposits while clay and silt rich zones may best be interpreted to be representative of low energy till, morainal , or lake sediment deposits.

The gamma logs did not clearly differentiate the unconsolidated sediments, either due to the mixing of the sediment types or to the homogeneous source material encountered by the glacier. The gravels are composed mainly of limestone fragments and contain only small percentages of igneous and metamorphic rocks brought southward by the ice sheets. The limestone gravels were derived for the most part from the underlying bedrock and probably were carried a relatively short distance from their original position (Klaer, 1948). A sample of gravels from the Skinner Landfill revealed a composition of 92% carbonate rock and 8% igneous or metamorphic rock (Struble, 1986).

In general, the more clay-rich sediments overlie the bedrock and fill in the buried valleys. This is consistent with clay-rich soils being interpreted as glacial till, as such sediments would be among the first to be deposited during a glacial advance. Clays occur at the surface along Skinner Creek and at the central and northern sections of the East Fork of Mill Creek especially near Dump Creek, where an undulating bedrock contact is visible. Clay-rich lenses also occur within the sands and gravels, possibly due to overbank deposits of streams or to ice or morainal-ponded lakes.

As described in Section 3.1, correlation of coarser sediments in the Cincinnati area can be made along the axes of the valleys while correlation across the valleys is less clear. The sand and gravel rich deposits, mined during the past gravel pit operation at the Skinner site, typically overlie or cut into the clay-rich sediments, supporting an outwash or stream origin.

The Skinner Landfill lies near the southern terminus of the Wisconsin age glaciation but glacial landforms are not distinct. The varied distribution of clays, sands and gravels indicates a complex glacial stratigraphy.

3.3.4 WASTE LAGOON AREA

Of the 19 borings completed in or around the buried waste lagoon, 15 encountered fill material with a maximum thickness of 26 feet being recorded at WL-10, a minimum thickness of 11.5 feet was observed at WL-16. An average fill thickness of 20.1 feet has been calculated. Table 3.1 shows fill thicknesses and includes estimates of the elevation of the natural soils. This debris is fully described on the boring logs. Typical descriptions include wood, plastic, metal, brick, wire, glass, paper and rubber. Fill material was mixed with soils at most locations.

In addition to the debris, several borings encountered tar-like material, oily sediments and sticky liquids described as raspberry and turquoise in color. These were found above the natural soils and below the debris and are interpreted to be related to the former lagoon. These materials were observed at depth in WL-05 (brown-black oily sand at 27' - 32'), WL-07 (turquoise blue, sticky fluid at 22' - 23'), WL-09 (black tar-like sand at 24.5' - 25.5'), WL-10 (raspberry colored liquid at 22'), and WL-14 (brown-black oily sand and gravel at 25' to 52.5'). These borings coincide with the apparent depression in the natural soils located beneath the debris, which may correspond to the former lagoon area. This depression in natural soils is indicated in Figure 3.13, a contour map of the natural soil elevations beneath the piled debris.

3.3.5 Buried Pit Area

Three borings, labeled BP, were drilled in or around the buried pit located near the Skinner residence. The material interpreted as fill in BP-01 included pieces of wood which would not be expected in naturally occurring sediments. The fill material is not readily differentiated from the naturally occurring soils although some black discoloration was observed at the 6 foot to 7 foot sample depth in BP-02.

3.3.6 Site Stratigraphy

The geology encountered on the Skinner site is typical of the Cincinnati area. Bedrock valleys, reflecting the preglacial drainage patterns, filled with sediments of glacial origin, are slowly being reexcavated by the post-glacial streams. These streams are also modifying the bedrock surface where limestone and shale are exposed. The glacial history is represented by the unconsolidated deposits which grade from clay to gravel, reflecting the cyclical depositional settings associated with an advancing and retreating ice sheet.

The contoured bedrock surface shown in Figure 3.12 reveals three buried valleys separated by bedrock highs. The east valley corresponds with the Skinner Creek channel, the central with the main access road to the active landfill area, and the west trending with the channel of the East Fork of Mill Creek. The third buried valley has been partially reexcavated by the East Fork of Mill Creek and bedrock is exposed in the creek bed as well as along the valley walls. The Skinner Creek bedrock valley is deeper and contains up to forty feet of glacial sediments, as revealed in the cross sections H-H' and I-I' illustrated in Figures 3.10 and 3.11.

Bedrock highs correspond to the metal storage area and the area to the north of the waste lagoon. The bedrock high to the north of the waste lagoon appears to be bluff-like in form, with elevations increasing from 733 feet at GW-17 to around 757 at GW-23, (Figure 3.12). The bedrock elevation at GW-23 is approximate due to the estimated stickup of 2 feet. This high slopes steeply to the central valley and to the Mill Creek Valley, but much less steeply between the two valleys. This central area, which roughly corresponds to WESTON's "central shoulder", passes beneath the waste lagoon. The bedrock high becomes long and narrow to the south of the buried lagoon, terminating in the erosional surface caused by the East Fork of Mill Creek.

The bedrock high beneath the metal storage area slopes steeply to the central valley and the ponds on the western side of the Skinner site. Bedrock outcrops at both the Diving and Trilobite Ponds and the contact appears to be sharply truncated by the Skinner Creek valley.

The central buried valley corresponding with the course of the main access road is shown in cross section A-A', (see Figure 3.4.) This cross section follows the valley axis. Relatively reliable correlations of the glacial sediments can be made down the valley axis, perpendicular to depositional strike. The lower unconsolidated unit shown in Figure 3.4, overlying the bedrock and extending from GW-26 under the East Fork of Mill Creek to GW31, consisting of a silty clay with some gravel and interpreted to be a till. Above this till is a more gravel and sand rich deposit with a silt component, interpreted to be outwash. The East Fork of Mill Creek flows on this unit near GW-38. The deposit exposed on the surface at GW-26 is again interpreted to be till and consists of a silty, sandy clay. The upper unit exposed on the surface at GW-15 is composed of a gravelly silt and sand. This is probably part of an outwash deposit, the one formerly mined by the Skinners for gravel. The surface deposit at GW-38, consisting of silty sand with some gravel, may be related to the surface unit at GW-15 or to the post-glacial erosional and depositional processes of the creek.

The units revealed in Figure 3.4 consist of the most obvious correlations of unconsolidated deposits on the site. Similar textures are seen elsewhere but may interfinger and grade into one another or be sharply truncated by a sediment of dissimilar texture. As mentioned previously, the correlations across the valley axes are not obvious.

The remaining cross sections (Figures 3.5 to 3.11) distinguish and correlate sediment textures based on gross characteristics. The unconsolidated sediments beneath and surrounding the waste lagoon demonstrate the possible variations and difficulties involved in their correlation. Attempts at these correlations are shown in Figures 3.5 to 3.9.

As noted on the cross sections, the lithologies described on the B-05 and B-08 drilling logs were not used. These logs indicate a gray shale at an improbable elevation. This unit is probably a hard till as seen in the Phase II boring BL-02 at a depth of approximately 15 feet: the blow counts are very similar but the lithologic descriptions vary significantly. Due to the lithologic controls provided by the additional drilling in the buried waste lagoon area during the Phase II investigation, the shaie recorded on the B-05 and B-08 was discounted. B-05 and B-08 well screens are indicated on the cross sections for the purpose of evaluating analytical results.

The debris mounded over the buried waste lagoon ranges in thickness from 11.5 feet to 20.1 feet and overlies a mixture of unconsolidated sediments. These sediments range in texture from silty clay with some gravel to gravelly sand with some silt. Unconsolidated sediment thickness is as much as 60 feet.

The cross sections, in addition to presenting lithology, were used to interpret ground water flow. Plotted by each well screen is the static water elevation in the well, as seen on May 15, 1990. The water elevation for GW-06, however, represents May 6, 1990, as this well had not recovered fully from sampling on May 15, 1990.

Water levels indicate a downward gradient occurs in most locations, from the unconsolidated sediments into the bedrock. Estimated water levels for the surface water bodies, based on the June 14, 1990, site survey, indicate a complex flow regime at the Skinner site. The hydrogeology of the site is investigated and discussed in Section 4.0.

SECTION 3

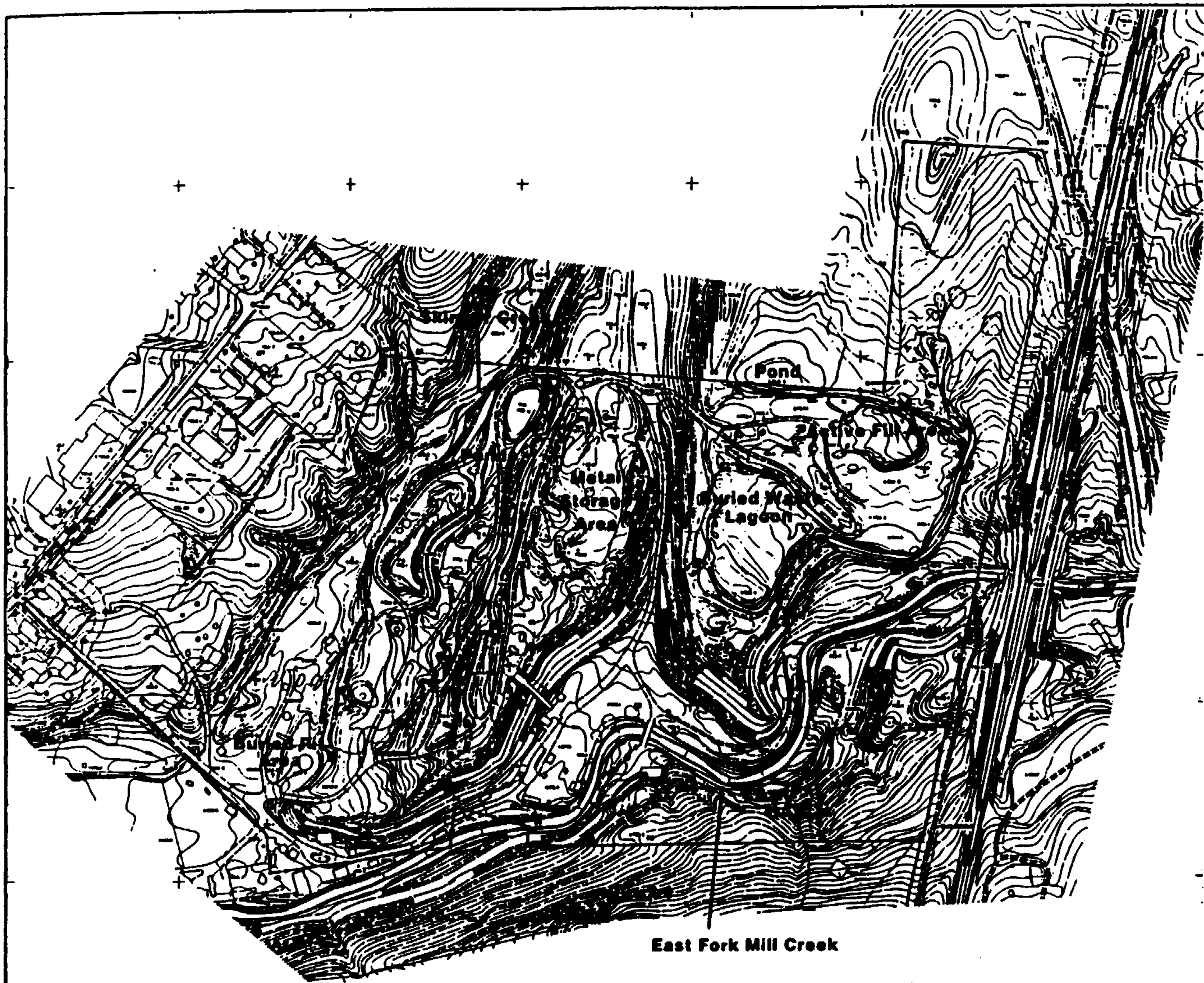
TABLES

Table 3.1
Waste Lagoon Area
Fill Thickness (in feet)

Boring ID	Surface Elevation	Boring Depth	Fill Thickness	Natural Soil Elevation	Boring Termination Elevation
WL01	753.9	27.8	17.5	736.4	726.1
WL02	749.8	27.5	15	734.8	722.3
WL03	750.8	32.5	15	735.8	718.3
WL04	747.3	28	16.5	730.8	719.3
WL05	757.3	45	24	733.3	712.3
WL06	753.4	32	24	729.4	721.4
WL07	751.4	35	22	729.4	716.4
WL08	749.3	31.2	17	732.3	718.1
WL09	760.8	45.7	25.5	735.3	715.1
WL10	756	34	26	730	722
WL11	753.3	32	22	731.3	721.3
WL12	750.5	34.5	17	733.5	716
WL13	729.6	40	0	729.6	689.6
WL14	762.3	59	25	737.3	703.3
WL15	754.5	48.5	23.3	731.2	706
WL16	752.7	20	11.5	741.2	732.7

SECTION 3

FIGURES

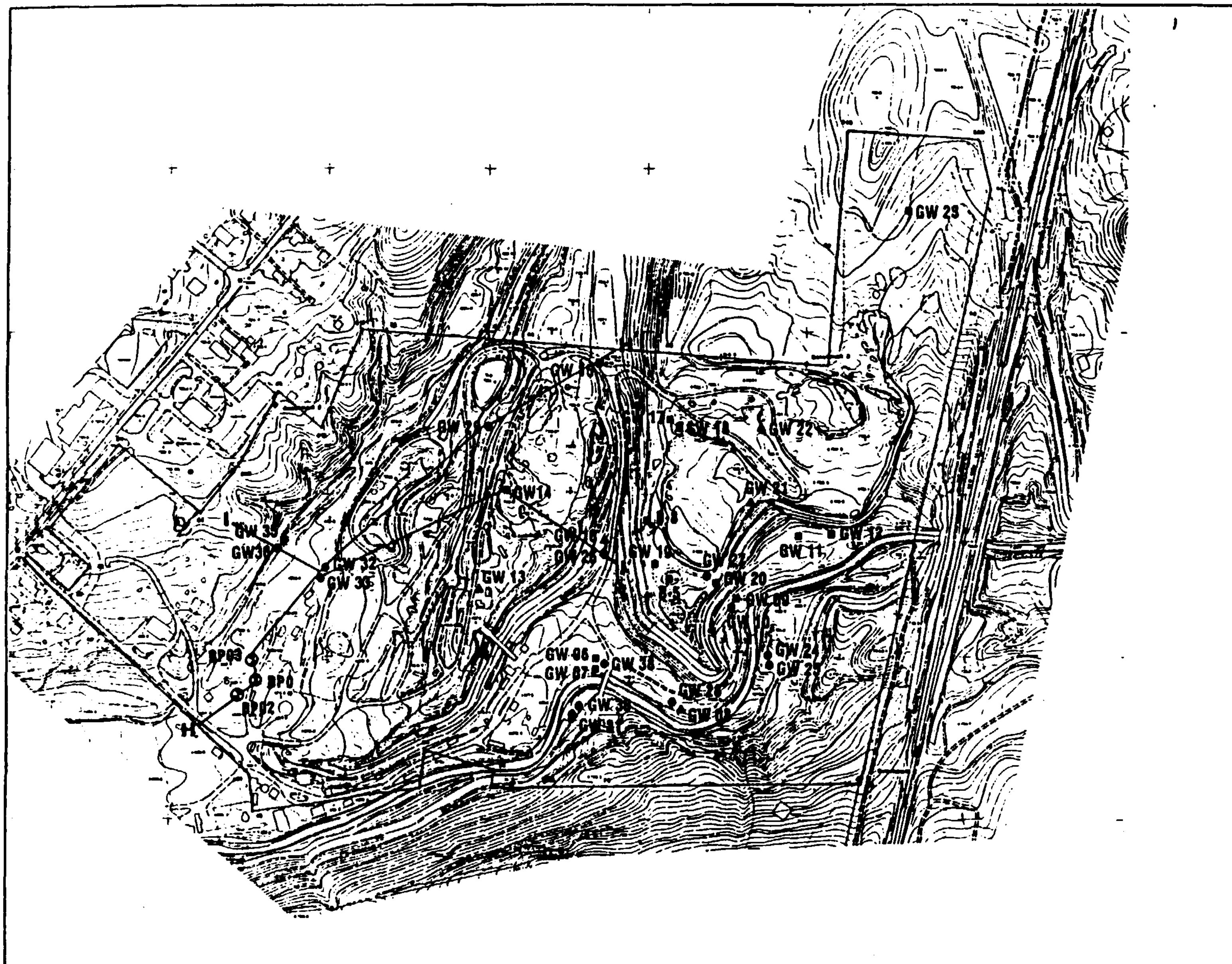


0 150 300 600
Scale in Feet

Figure 1.2, 3.1
Topographic Map

SKINNER LANDFILL
West Chester Ohio

March, 1991 04003 15



LEGEND

- ● Monitoring Well (Phase II)
- ■ Monitoring Well (pre-Phase II)
- ▲ Abandoned Monitoring Well

N

0 150 300 600

Scale in Feet

Figure 3.2

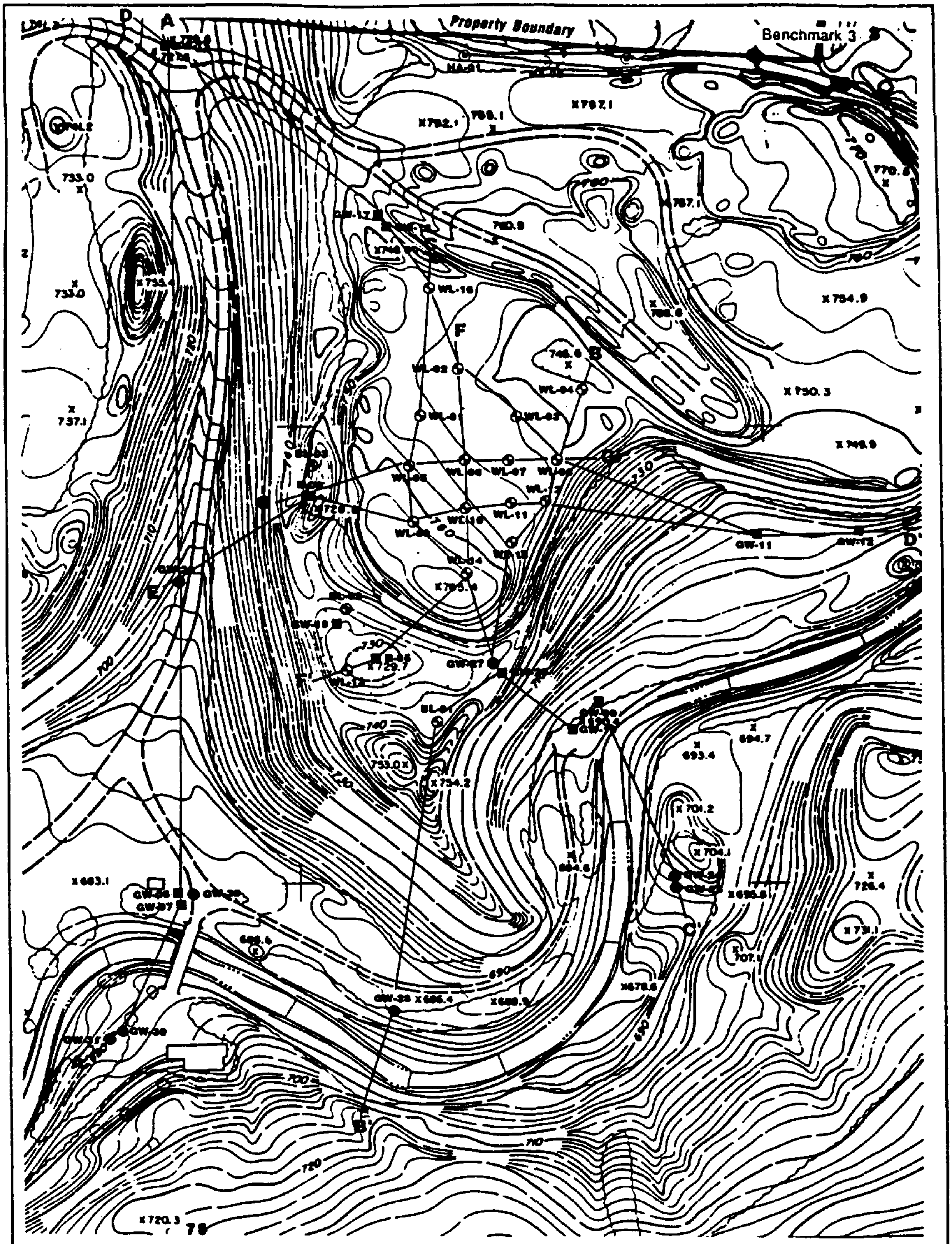
Site Map with Cross Section Traces

Skinner Landfill

West Chester, Ohio

February, 1991

04003 14



LEGEND

- ■ Pre Phase II Wells
- ◎ Hand Auger
- ● Soil Boring/Monitor Well
- ⊗ Soil Boring

N

0 50 100 200

Scale in Feet

Figure 3.3

WASTE LAGOON AREA with Cross Section Traces

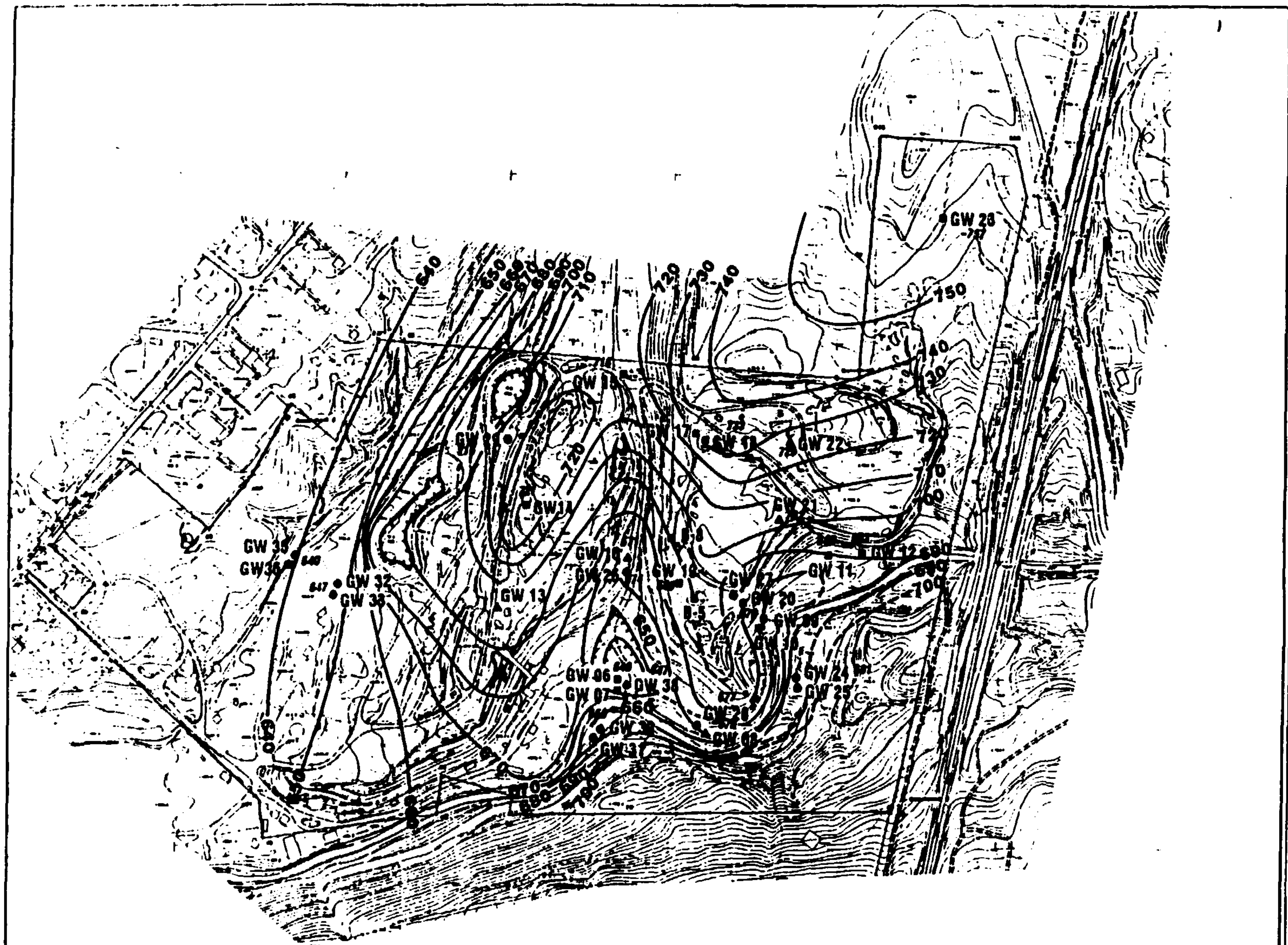
Monitor Well and Soil Boring Location Map

Skinner Landfill

West Chester, Ohio

November, 1990

04003.14



LEGEND

- ● Monitoring Well (Phase II)
- ■ Monitoring Well (pre-Phase II)
- ▲ Abandoned Monitoring Well

NOTE:
Elevations derived from Phase I wells, Phase II wells, Weston's Seismic Survey and Bedrock Outcrops.

0 150 300 600
Scale in Feet

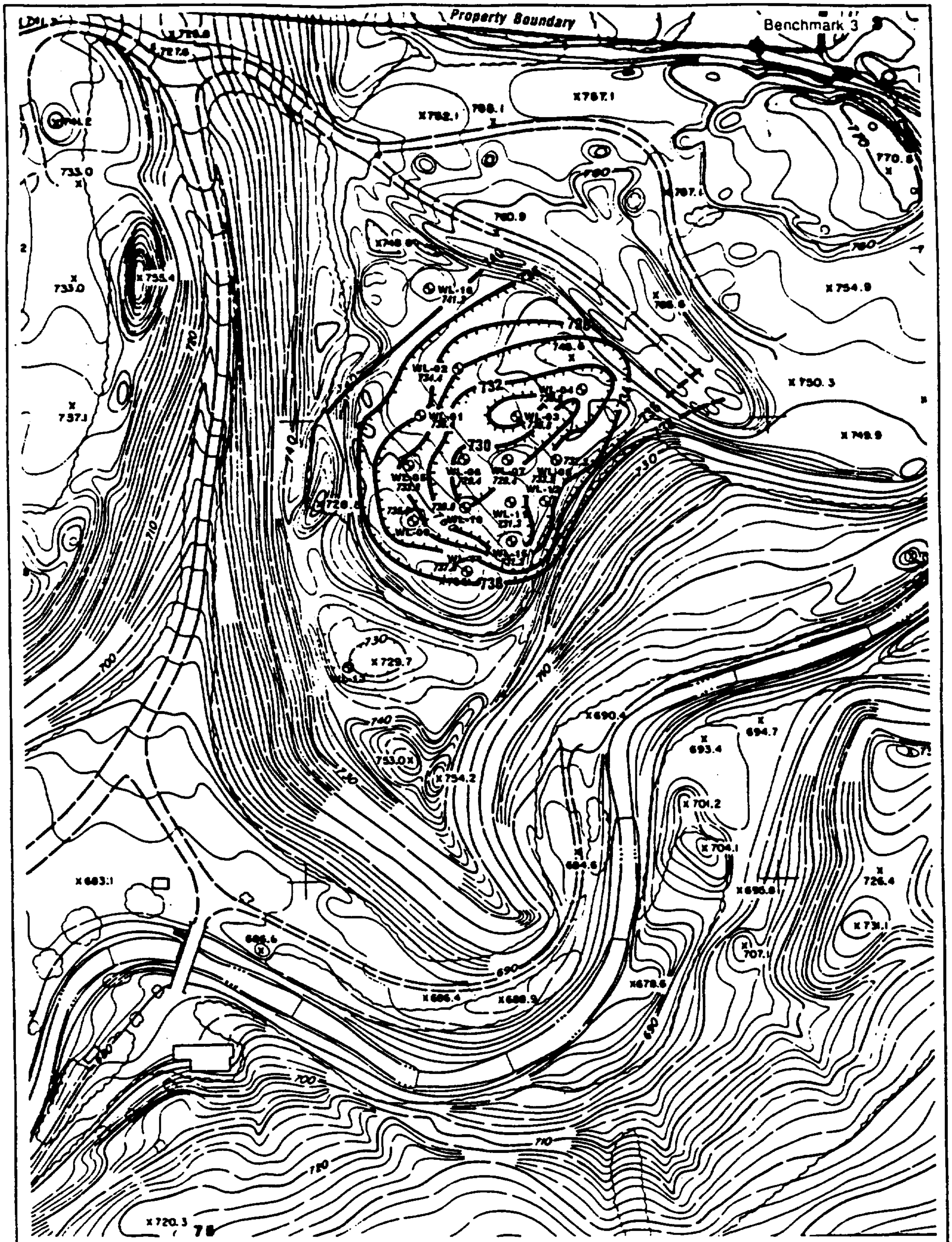
Figure 3.12

BEDROCK ELEVATION MAP

Skinner Landfill
West Chester, Ohio

February, 1991 04C03.14

WW Engineering & Science



LEGEND

Soil Boring

Contour Interval = 2 ft.

0 50 100 200

Scale in Feet

Figure 3.13

WASTE LAGOON

Elevation Contour Map
Top of Natural Soil

Skinner Landfill
West Chester, Ohio

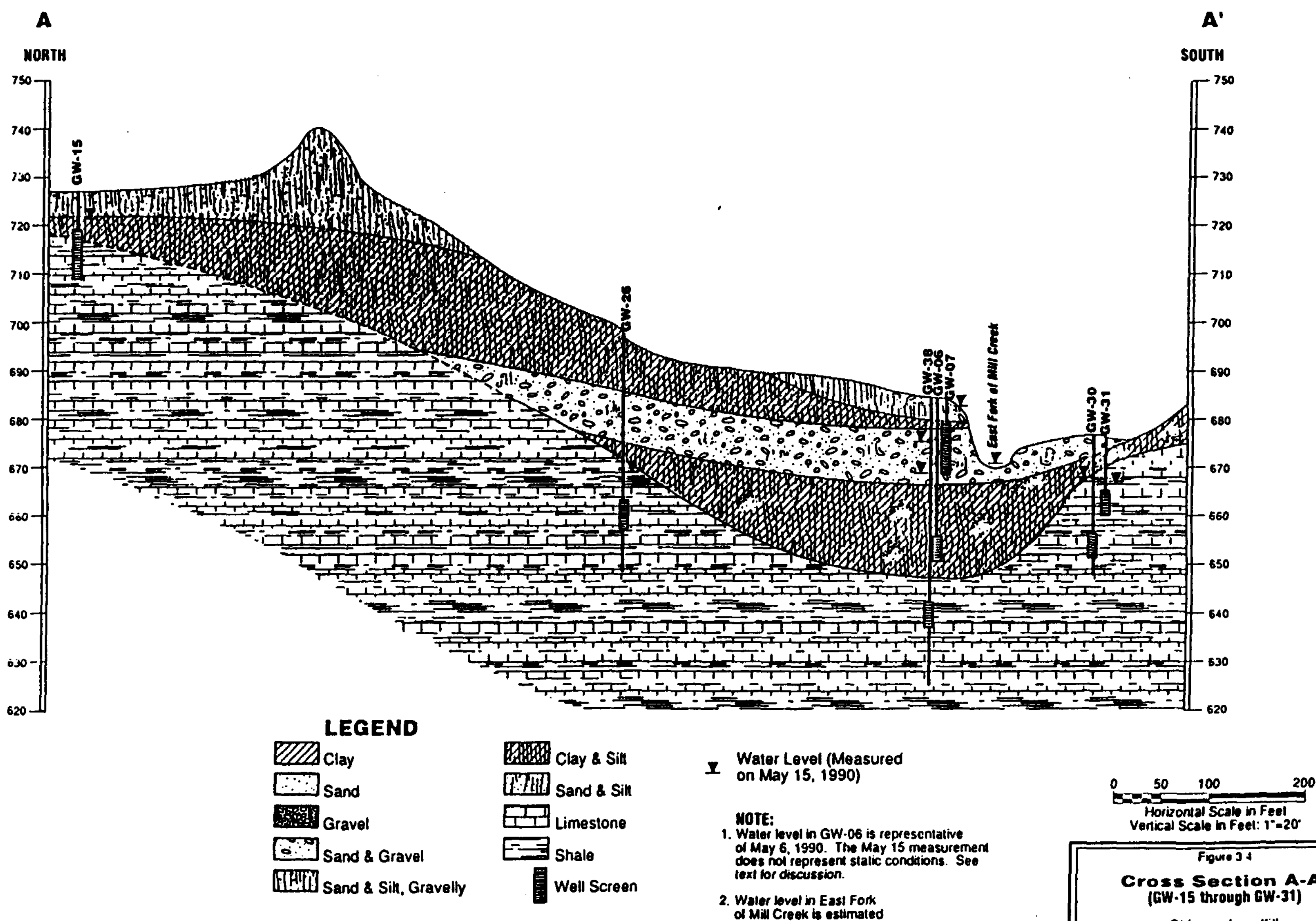


Figure 3 4

Cross Section A-A'
(GW-15 through GW-31)

Skinner Landfill
West Chester, Ohio

February, 1991 04C03 14

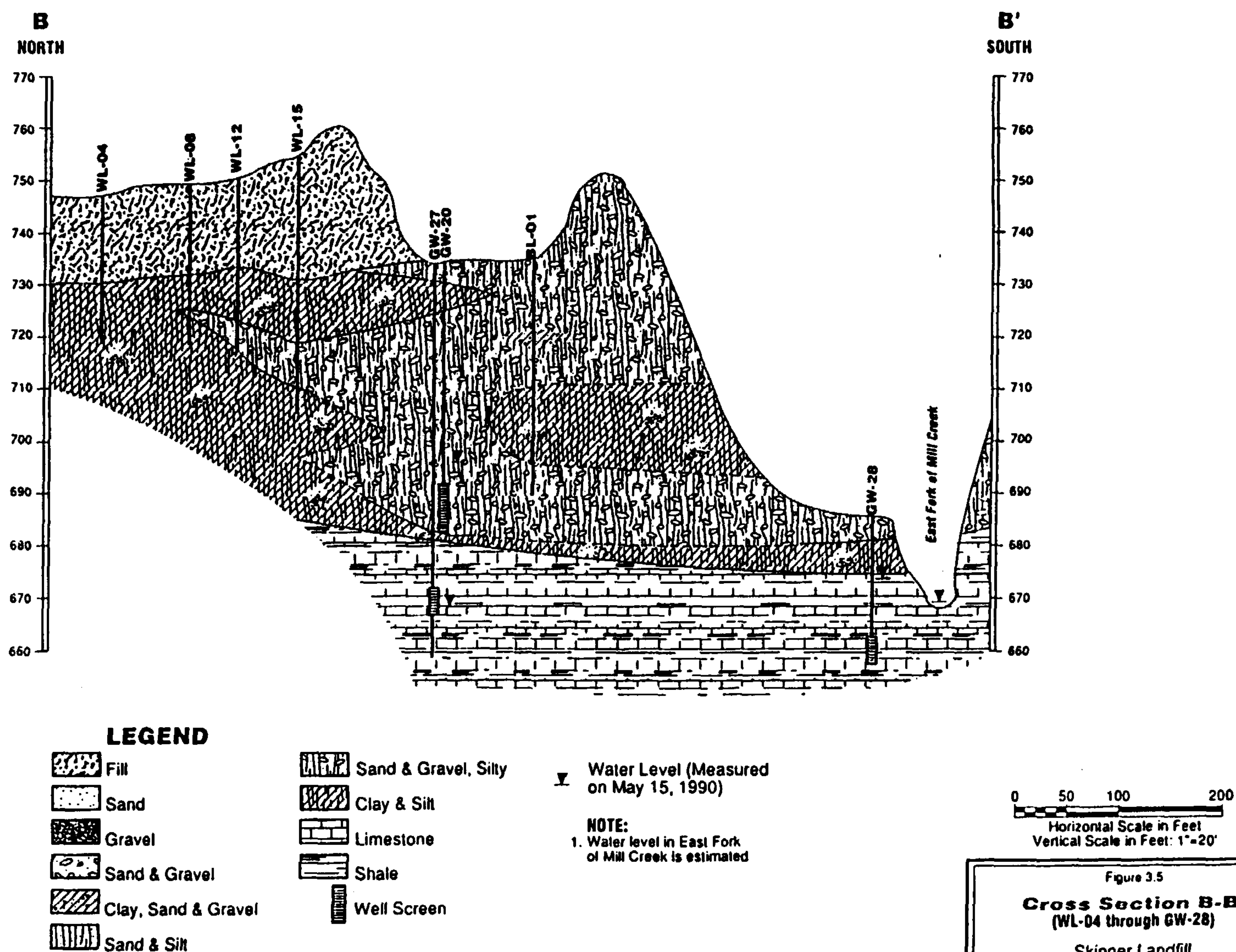


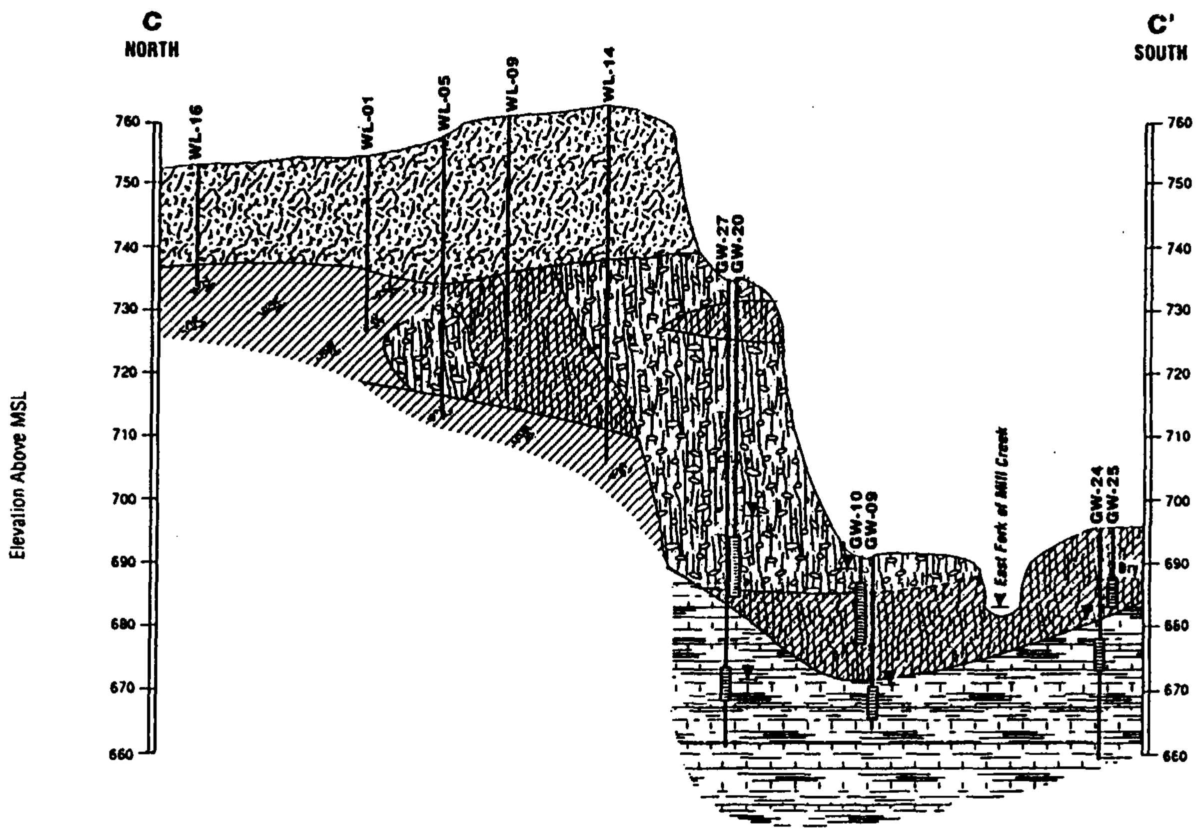
Figure 3.5

Cross Section B-B'
(WL-04 through GW-28)

Skinner Landfill
West Chester, Ohio

February, 1991

04003.14



LEGEND

- Fill
- Clay
- Sand
- Sand & Gravel
- Sand & Silt
- Silty Clay
- Limestone
- Shale
- Gravel & Sand, Silty
- Well Screen

Water Level (Measured on May 15, 1990)

NOTE:
1. Water level in East Fork of Mill Creek is estimated

0 50 100 200
Horizontal Scale in Feet
Vertical Scale in Feet 1"=20'

Figure 3.6

Cross Section C-C'
(WL-16 through GW-25)

Skinner Landfill
West Chester, Ohio

February, 1991 04003.14

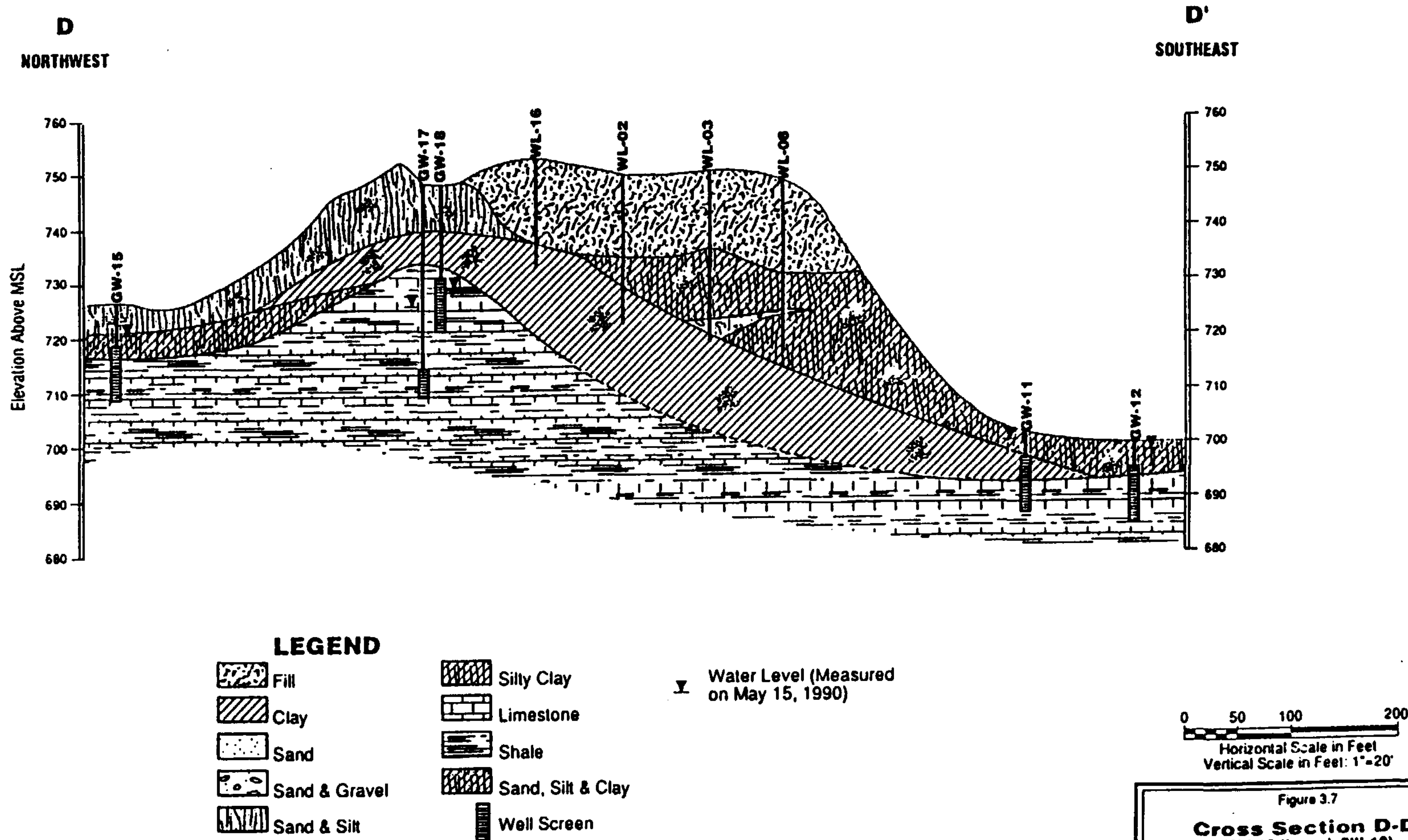


Figure 3.7

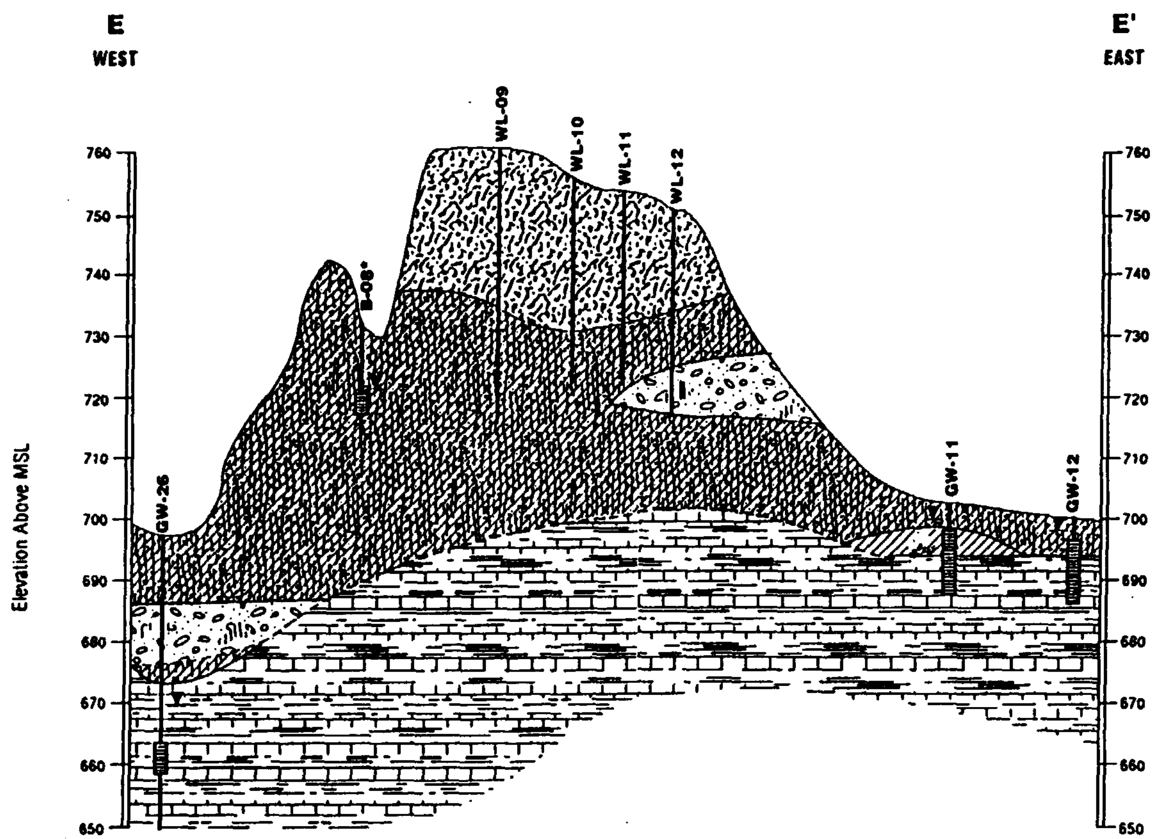
Cross Section D-D'
(GW-15 through GW-12)

Skinner Landfill
West Chester, Ohio

February, 1991

04003 14

WW Engineering & Science



LEGEND

- Fill
- Clay
- Sand
- Sand & Gravel
- Silty Clay
- Clay, Silty, Sandy, Some Gravel
- Limestone
- Shale
- Well Screen
- Water Level (Measured on May 15, 1990)

*B-08 Described lithology is unreliable - well shown for water level and sampling purposes. See text for discussion.

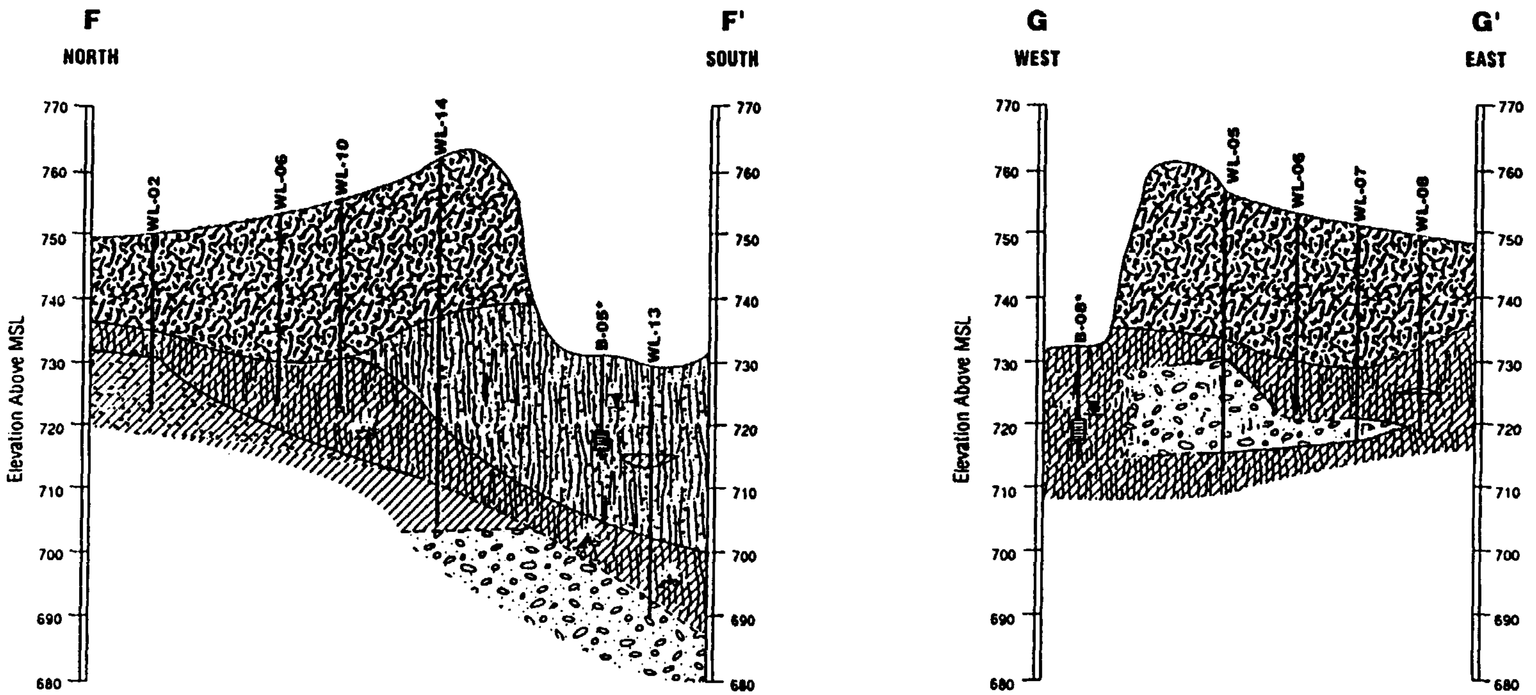
0 50 100 200
Horizontal Scale in Feet
Vertical Scale in Feet: 1"=20'

Figure 3.8

Cross Section E-E'
(GW-26 through GW-12)

Skinner Landfill
West Chester, Ohio

February, 1991 04033 14



LEGEND

- Fill
- Clay
- Sand & Gravel
- Sand & Silt
- Sand & Gravel, Silty
- Silty Clay
- Limestone
- Shale
- Bedrock
- Well Screen
- Water Level (Measured on May 15, 1990)

*B-05 Described lithology is unreliable - well shown for water level and sampling purposes. See text for discussion.

*B-08 Described lithology is unreliable - well shown for water level and sampling purposes. See text for discussion.

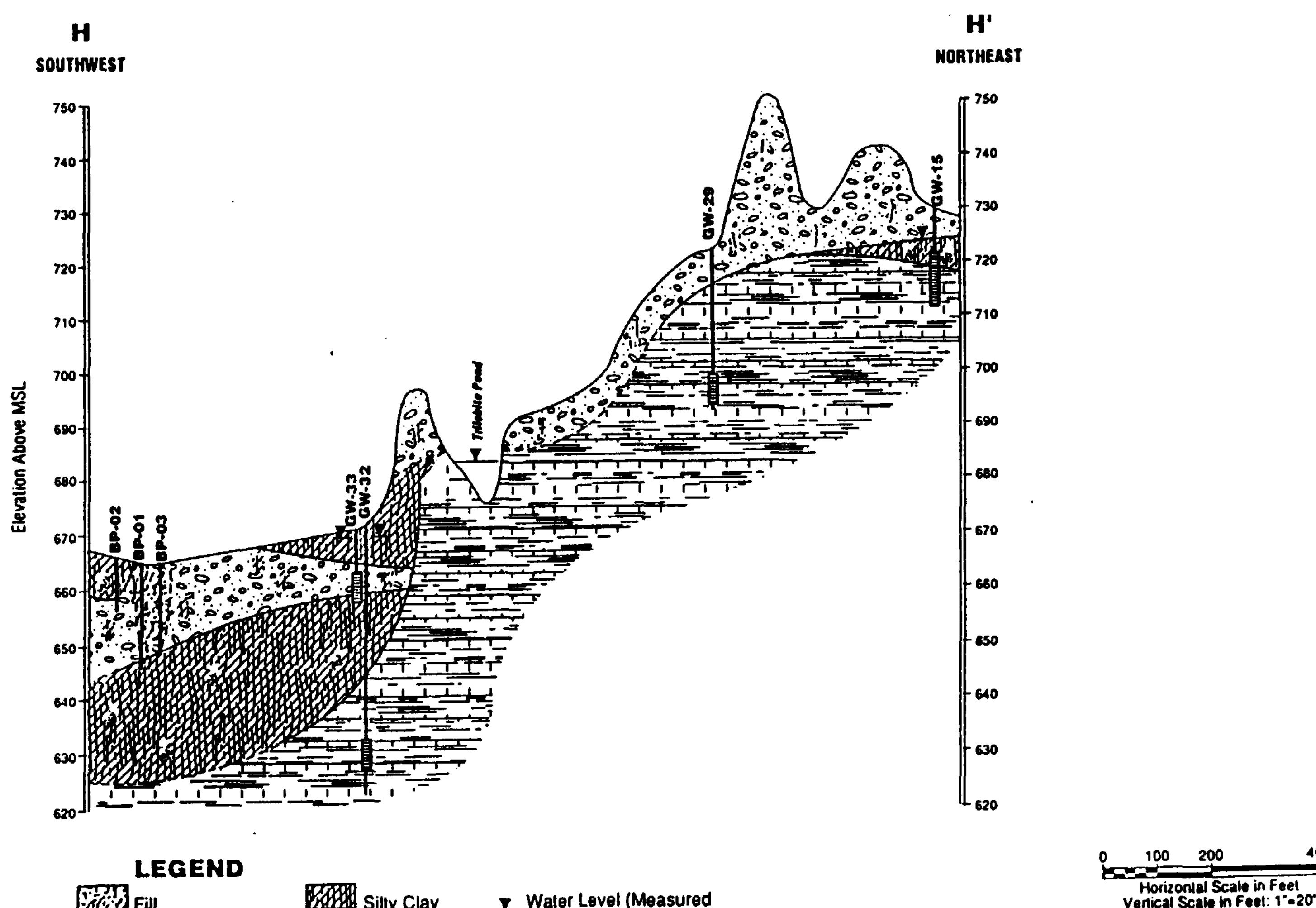
0 50 100 200
Horizontal Scale in Feet
Vertical Scale in Feet: 1"=20'

Figure 3.9

Cross Section F-F' and G-G'
(WL-02 through WL-13 and B-08 through WL-08)

Skinner Landfill
West Chester, Ohio

February, 1991 04003 14



NOTE:
1. Water Elevation in Trilobite Pond determined from revised survey map (6-14-90).
2. Elevation of bedrock surface beneath borings is inferred from Weston's bedrock topography map.
3. Northeast extent of buried pit estimated from historical aerial photographs.

Figure 3.10

Cross Section H-H'
(BP-02 through GW-15)

Skinner Landfill
West Chester, Ohio

February, 1991

04003 14

4.0 HYDROGEOLOGY

This section defines the hydrogeologic characteristics of the study area. The major hydrogeologic units are identified and contrasted and the permeabilities of the saturated sediments found beneath the site are discussed. In addition, the ground water flow characteristics and the hydraulic relationships of the glacial and bedrock formations are evaluated. The hydraulic relationships between ground and surface waters were evaluated by examining the variation in water level elevations measured within the monitoring wells and surface water bodies in addition to an examination of the chemical characteristics of the various water types.

4.1 CLIMATIC CONDITIONS

The mean annual temperature on record at the Abbe Observatory in Cincinnati is 54.9 degrees F., and the average monthly temperatures range from 32 degrees in January to 77 degrees in July. The average monthly precipitation is nearly the same throughout the year, but is generally above the average during March, April and May and less during September, October and November. Yearly average precipitation is 39.34 inches. The maximum recorded rainfall in a 24 hour period was 4.77 inches and occurred during 1933.

4.2 REGIONAL HYDROGEOLOGIC UNITS

The principal sources of ground water in the Cincinnati area are the deposits of sand and gravel, interbedded with lenses of clay and silt, that fill the valleys of the pre-glacial drainage systems. These deposits are among the most productive aquifers of glacial origin in the United States. Due to the abundant amount of fresh water obtained from the glacial deposits in the Cincinnati area and the comparatively poor production from wells screened in the bedrock, information regarding the bedrock hydrogeology is lacking and much must be inferred from the literature.

4.2.1 UNCONSOLIDATED DEPOSITS

The hydraulic properties of the glacial deposits are as complex as their geology. As discussed in Section 3.1, the glacial sediments exhibit a great degree of textural variability and the correlation of an individual stratum from one locality to another is often problematical. While there may be localized clay-rich confining layers, nearly all of the glacial sediment units have sufficient permeability to permit recharge by vertical leakage to the underlying deposits, especially under the stress of pumping (Speiker, 1961).

4.2.2 Bedrock

Bedrock units are not commonly used as major aquifers in southwestern Ohio. Some of these lithologic units yield enough water for farm or domestic supplies, and in parts of the upland areas where the glacial drift is impermeable, thin, or absent, they constitute the only available sources of water. According to Speiker, availability of water in these formations, especially of the Ordovician system, is difficult to predict, owing to local variations in the fracture and joint systems and the bedding plane openings, which are the main sources of water. A few wells drilled into rocks of Cincinnatian age yield as much as 5 gpm while others are dry (Speiker, 1961).

A general discussion of ground water occurrence and movement in the gently dipping to flat lying Ordovician carbonate rocks is presented by Seaber (1988):

> Ground water distribution in rocks of Ordovician age in this subregion is highly variable. Except for the anisotropic and nonhomogeneous development of secondary openings, much of the limestone has extremely low porosity and permeability and functions as an aquitard. Large solution openings are relatively uncommon.

The fracture system and the bedding planes combine to control ground water movement and distribution in the bedrock.

The interbedded shale layers form locally thick barriers to vertical water movement. Fracture development in the shale, providing conduits between the limestone layers, is unknown. However, Davis (1988) provides a discussion of the importance of such fractures, if they should occur.

> Secondary fractures add a small but important porosity, commonly less than 1%, to shale near the surface. A soft shale with an abundant clay component may not retain significant fracture openings beyond depths of only 30 meters. In contrast, brittle shale with large amounts of silica...can maintain abundant open fractures at depths greater than 300m. Nevertheless, the total

amount of porosity added to shale by secondary fractures is probably very small, although general studies of this question are evidently lacking.

The porosity of most shales decreases with depth due to increasing density and the probable closing of fractures. The shales encountered at the Skinner site were soft to slightly brittle, therefore the development of significant fracture systems through the shale units is improbable.

The fracture system and bedding planes represent the only important routes for ground water movement in the bedrock. However, the fractures occurring near the bedrock surface may be partially blocked by the silts and sand of the overlying glacial deposits. Sediment infilling, as described by Brahana (1988), is caused by clay and sand particles, transported in the flowing ground water, filling the voids of a carbonate aquifer and reducing secondary porosity. This process can choke an aquifer by filling its transmissive zones with fine-grained sediment. Conduits in an aquifer in which flow velocities are inadequate to transport the sediment load they receive will be plugged. Infilling generally occurs under fluvial conditions, but has been reported from glacial settings as well.

The flow within the bedrock is controlled by the limestone fracture system, the aquitard properties of the shale layers, and the density of the limestone. Infilling may create a boundary layer of undetermined thickness in the upper bedrock with porosity and permeability even lower than those in the deeper bedrock, causing preferential ground water movement within glacial sediments down the buried slopes of bedrock valleys. The infilling of fractures, combined with the probable inhibiting effects to vertical flow of the shale layers would cause the hydraulic heads in the glacial aquifers to be greater than those in the bedrock. Regional flow in the bedrock would have a preferential horizontal component and a generally downward vertical gradient.

4.3 RESULTS OF PERMEABILITY TESTING

In situ permeability tests were conducted on existing Phase I monitoring wells constructed by WESTON and on wells constructed by WWES during the second phase of the RI/FS. All Phase II monitoring wells were developed prior to testing. The results of the permeability testing, in units of feet/day, are reported in Table 4.1. The well parameters for the Phase I wells were taken from WESTON's Phase I report; however, water level recovery information is taken entirely from Phase II testing. A summary of all Bouwer-Rice slug test analysis method input parameters is provided in the Methods section (2.6).

Some differences exist between the permeability values reported by WESTON during Phase I and those determined by WWES during Phase II. There is a greater than 100 fold variation in bedrock permeabilities in the Phase II permeability values while a 10 fold variation exists in Phase I results. A greater variation might be expected in the Phase II testing results as a number of such wells has increased significantly as part of this investigation. The slug testing of a larger number of bedrock weils shows a corresponding greater variance in estimated permeabilities. This is a direct result of the non-homogeneous nature of the bedrock with its varying bedding layer thicknesses and the possible discontinuity of fractures. Estimated permeabilities for the unconsolidated sediments agree more favorably between the two phases of testing.

A review of the data plots presented in the Interim Phase I RI/FS indicate that test results which display a double straight line effect were typically the source of the observed difference between Phase I and II data. The early straight line segment was chosen by WESTON for input into the Bouwer-Rice calculation. As described above, this early-time line segment can result in erroneously high permeability values due to the influence of the sand pack and developed zone around the well (Bouwer, 1989); therefore, the Phase II test results will be used in decision making for the RI/FS. An exception to this approach is necessary, however, as Phase II testing did not evaluate all of the textural sediment varieties encountered. Therefore, the permeability obtained from Phase I testing of GW08 will be used to represent the fine, silty sands present at the site. Average permeability values for each major lithologic/textural unit encountered are shown in Table 4.1.

The results of the permeability testing range from 0.0298 to 22.7 ft/day with the majority, eight values and a duplicate, falling in the 0.1 - 1.0 ft/day range. Six values were greater than 1.0 ft/day while two were less than 0.1 ft/day. The higher values were measured both in bedrock wells and those screened in the overlying unconsolidated soils. Therefore, spatial variability in permeability is present in both the unconsolidated and bedrock units. Variations in permeability values in bedrock units are predominantly controlled by the number and development of bedding planes and fractures, or, in the case of GW-17 and GW-18, possibly by the apparently anomalous lithology "pebbly-shale" as described by WESTON.

Due to the chosen stress method (applying either a vacuum or pressurizing the well), tests could not be completed on wells where the water table intersected the screen. Hydrodynamic displacement of formation water, which is essential for meaningful results, cannot be achieved under such conditions. Thus, the results presented are solely those of wells with screens set below the water table. Monitoring wells GW27 and GW29 were not tested due to water levels below the top of the screen interval and GW25 was dry at the time of testing. GW06 was not tested due to the presence of oil in the well, discovered during geophysical logging and ground water sampling.

A comparison of the hydraulic conductivity values obtained at the Skinner Landfill Site with values presented by Davis (1969), Freeze and Cherry (1979) and Driscoll (1986) indicates consistency with similar types of sediment and bedrock found elsewhere. The results provide order-of-magnitude estimates of the hydraulic conductivities at the Skinner site which can be used to approximate the ground water flow velocities and discharge volumes.

4.4 SITE SPECIFIC WATER OCCURRENCE AND CHEMISTRY

4.4.1 GENERAL WATER CHEMISTRY

An examination of the major ions and cations found in the various water samples was performed to evaluate the likelihood of hydraulic communication between the various water sources. Stiff diagrams, which are graphical representations of major ion concentrations, were prepared to identify patterns associated with particular hydrogeological environments and hydrostratigraphic units as determined from representative water sources. The chemistry of water is variable and depends on the mineralogy of the materials with which the water has been in contact, biological activity, interaction with the atmosphere and the effects of human activity.

Glacial Deposits

The ground water present in the glacial deposits, as illustrated in Figure 4.1, can be characterized as calcium-bicarbonate water. This finding confirms Spieker's statement (1961) that the general chemical composition of water in the glacial outwash aquifers of southwestern Ohio is of the calcium-bicarbonate type and is fairly uniform. GW-20, screened at depth adjacent to the buried waste lagoon, contains greater amounts of bicarbonate than other water samples and appears to be more mineralized. GW-07, the upper well in the cluster adjacent to East Fork of Mill Creek, is unusual because it contains a greater amount of magnesium than calcium.

Bedrock

Ground water obtained from wells screened in the bedrock (Figures 4.2 and 4.3) reveal several groupings based on chemical characteristics. The stiff diagrams representing ground water from GW-38 and GW-30 are similar in form and indicate sodium chloride type ground water. GW-27 and GW-09 demonstrate slightly more calcium-bicarbonate character compared to the sodium-chloride nature of GW-38 and GW-30. GW-09 and GW-27 appear to represent a mixing of bedrock water with water from the unconsolidated sediments. GW-26 appears to represent water which is chemically similar to GW-09 and GW-27 but dominated by chloride rather than bicarbonate. Water from GW-28 is unique, being dominated by sodium, potassium and chloride. The remaining water samples are bicarbonate in nature but are influenced to different degrees by the various cations.

According to Speiker (1961), water from bedrock in this region is usually hard, has a high iron content and sometimes contains objectionable amounts of hydrogen sulfide and sodium chloride. With the exception of the iron content, which is less than may be regionally common, the water obtained from the bedrock wells on the Skinner site is typical of the region.

The calcium-bicarbonate pairing and the consistent magnesium concentrations are typical of water derived from limestones while the sodium, potassium and chloride ions may originate in the shales. The sulfate revealed in the glacial deposit water is not seen at similar concentrations in most bedrock wells and may originate from an anhydrite or gypsum source carried south by the glaciers. The generally low concentrations of sulfate in the bedrock water may indicate very slow local recharge while the higher concentrations found in GW-28 and GW-24 may indicate areas of more rapid local recharge and greater influence of water derived from the glacial deposits. Both of these wells are located adjacent to the East Fork of Mill Creek in locations where the overlying glacial deposits are entirely unsaturated, indicating rapid vertical drainage.

The bedrock well cluster comprised of GW-30 and GW-31 allows a comparison of bedrock ground water chemistry with depth. The shallow well (GW-30) in the cluster contains calcium-bicarbonate water similar to the water encountered in the glacial deposits. The deeper well (GW-31) has higher relative concentrations of sodium, potassium and chloride which may be indicative of a longer bedrock residence time or of greater interaction with shale.

Water obtained from wells straddling the unconsolidated-bedrock contact are presented in Figure 4.4. These wells reveal a unique chemistry, possibly related to their proximity to the landfill or to the mixing of water types. GW-11 contains a calcium-sulfate water while GW-12 contains calcium-bicarbonate water with significant amounts of sulfate.

The analysis of the surface water samples, presented in Figure 4.5 through Figure 4.8, reveals water chemistry similar to that found in ground water occurring in the unconsolidated sediments (calcium-bicarbonate type). This suggests that the streams and ponds are likely to be hydraulically connected with the ground water in the unconsolidated sediments.

4.4.2 Surface Water

Two small creeks and a series of ponds are the predominant surface water features at the site. Two of the ponds which were formerly located on the west side of the site no longer exist. One has been filled in and two others have been combined to form one pond. The topographical alterations are the results of excavation activities conducted by the landfill operator, Ray Skinner, in late 1989.

Skinner Creek has an average gradient of 0.014, an estimated average flow of 2 cubic feet per second and flows entirely on the unconsolidated sediments within site boundaries. The East Fork of Mill Creek is a rapidly flowing stream with an average gradient of 0.013 and an estimated average flow of 10 cubic feet per second. This creek flows on bedrock on the southern portions of the site, is very flashy, and is capable of scouring sediments during flooding. Such scouring may transport contaminated sediments off the Skinner site, if and when present in the stream bed.

4.4.3 Ground Water Flow Conditions

As described in WESTON's Interim Phase I report and confirmed by the Phase II work performed by WWES, the subsurface deposits at the Skinner site can be divided into two hydraulically connected hydrostratigraphic units. These two units are an unconsolidated outwash sand and gravel unit and a bedrock unit.

4.4.3.1 Ground Water Flow in Unconsolidated Sediments

Water level elevations in the completed wells were measured during the Phase II field investigation; one nearly complete set was measured on May 6, 1990, and complete sets of measurements were obtained on May 15 and July 19, 1990, and February 7, 1991. These water level elevations are presented in Table 4.2.

The water table contour maps presented in Figures 4.9, 4.10, and 4.11 were prepared by hand contouring the water level elevations measured in the wells screened in the unconsolidated sediment. Water level elevations measured in wells screened straddling the bedrock contact and nearby surface water elevations were also used in preparation of these maps. Ground water elevations mapped from the three distinct measuring events display similar ground water flow conditions. This demonstrates consistent flow patterns from the spring through the summer months. The fourth round of water levels, taken February 7, 1991, reveal similar flow patterns. This round of water levels may not be indicative of all winters as significant rainfall had occurred periodically during the week preceding the measurements.

Ground water elevations in GW-18 and GW-28 were also included in the water table contour maps as they represent locations where the water table and the bedrock intersect. GW-18, located in the well cluster to the northwest of the buried lagoon, is screened in a local bedrock high as seen in the cross section presented in Figure 3.7. Ground water found in this section of bedrock is apparently in hydraulic connection with the unconsolidated sediments through a possible weathered zone or through the bedding planes and fractures as evidenced by water elevations and water chemical characteristics. WESTON reported GW-18 as being dry during their third round of sampling, which took place in 1987. GW-28, located downgradient from the waste lagoon and adjacent to the East Fork of Mill Creek, was screened in the bedrock below the completion depth of GW-08. GW-08 was abandoned during the Phase II investigation as it was screened in the vadose zone.

As shown in the contour maps, two ground water divides exit in the unconsolidated sediments. The first, designated the western divide, lies beneath the topographic high on the west of the main access road near the metal storage area. The second, designated the eastern divide, trends approximately north-south through the active landfill and the buried waste lagoon. Both of these divides coincide with previously described bedrock highs.

Horizontal flow in the glacial sands and gravels is from the divides toward Skinner Creek, the East Fork of Mill Creek or the bedrock valley parallel to the main access road in the center of the site. Based on a comparison of ground water elevations and surface water elevations, ground water flowing west from the western ground water divide appears to discharge to or flow beneath Skinner Creek. Ground water that flows eastward from the western divide and westward from the eastern divide appears to flow along the axis of the bedrock valley parallel to the main access road, to the East Fork of Mill Creek. Ground water originating on the east side of the waste lagoon also flows toward Mill Creek.

The construction of the waste lagoon soil borings revealed saturated sediments at varying elevations. As the borings were not constructed for the purpose of evaluating ground water elevations within and below the buried waste lagoon, the relationship of the saturated sediments beneath the waste lagoon to the water table in the unconsolidated sediments, as presented in Figures 4.9, 4.10, and 4.11, is uncertain. The impacted sediments beneath the lagoon were observed to extend downward to an elevation of approximately 715 feet at the lowest point. Based upon the water level contour maps, the elevation would be within or just above the water table elevation projected beneath the lagoon.

The physical base of the lagoon, as interpreted in Figure 3.13, does not extend into the water table. The drilling logs note, however, that water levels in the augers were measured to be within the actual lagoonal sediments. This water may be perched and overlie less permeable sediments or represent the infiltration and migration of precipitation through the unsaturated zone. Water levels measured through augers during drilling operations are typically not representative of static conditions.

4.4.3.2 Rate of Ground Water Flow

Ground water flow velocities within the unconsolidated sediments were calculated for two flow vectors radiating from the buried waste lagoon. These two flow vectors intersect different sediment types with corresponding variations in permeabilities. Gradients were chosen parallel to the direction of flow. Permeabilities were estimated using the Bouwer-Rice *in situ* method (see Section 4.3). Average permeabilities for the varying sediment types were used in the calculations.

Flow rates were calculated using a simplified version of Darcy's Law:

Average flow velocity = Hydraulic gradient X permeabilities/porosity. The porosity values were inferred from literature sources (Driscoll, 1986).

The area between the buried waste lagoon and GW-10 had an average hydraulic conductivity of 9.86 ft/day and a porosity of approximately 35 percent. These values represent sand/gravel and fine silty sand. The hydraulic gradient was 0.12, producing a flow velocity of 3.38 ft/day toward the East Fork of Mill Creek.

Between the waste lagoon and GW-06 an average permeability of 0.275 ft/day and an approximate porosity of 40 percent, representing a clayey till, were used. The hydraulic gradient was 0.10, producing a flow velocity of 0.069 ft/day.

The ground water flow velocity calculations presented above assume ground water flow through a homogeneous media. It is likely that the heterogeneous textures of the soils surrounding the waste lagoon inhibits normal Darcian flow conditions. Additionally, the very steep apparent hydraulic gradient (0.1 to 0.12) may artificially inflate ground water flow velocities.

4.4.3.3 Ground Water Flow in Bedrock

Ground water flow in the bedrock is very poorly defined. The placement of the Phase II monitoring wells for optimal detection of contaminants necessitated that their screens be positioned within twenty feet of the bedrock surface. As shown in Figure 3.12, this surface has a great deal of relief. The result is that the wells screened in the bedrock vary in elevation by as much as 95 feet, intersecting different bedding planes and, potentially, fractures. The ground water elevations in these wells represent varying potentials with little or no relationship to each other. Water elevation maps such as those presented for the unconsolidated sediments would have only local meaning where there are wells screened at similar elevations.

As discussed in the previous sections, ground water levels from bedrock wells agreeing with the unconsolidated ground water contours were included as data points on the contour maps illustrating water table elevations. Such agreements may indicate locations where the water table dips into the bedrock or where the bedrock rises above the water level in the unconsolidated sediments. The water flowing through the bedrock mound associated with GW-17 and GW-18 may be more closely related to the unconsolidated sediments.

The borehole temperature logging program was designed to assist in determining the flow patterns in the bedrock. Temperature gradient anomalies occur in the bedrock, typically associated with the boundary of a thick shale and a limestone, indicating preferential flow zones at such points. The shale layers may be thick enough to impede downward flow and force flow along the contact between the two rock types. This confirms the conclusion that flow along the bedding planes/fractures is the principal means of transmission of water in the bedrock and that the bedrock density and limited permeability inhibits vertical ground water flow, as demonstrated by the Stiff diagram water chemistry comparison.

4.4.3.4 Vertical Gradients

Vertical gradient calculations were performed on well clusters across the Skinner site. The results of these calculations are presented in Table 4.3

A downward gradient exists across the Skinner site from the glacial deposits into the bedrock. The magnitude of this gradient ranges from almost zero near to and around Skinner Creek to 1.29 at GW-20/GW-27, located on the uplands to the south of the buried waste lagoon.

Within the bedrock, however, the gradient orientation seems to vary. Two well clusters were screened entirely in the bedrock. The gradient at well cluster GW-17/GW-18, located in a bedrock high to the northwest of the buried waste lagoon, is downward with a magnitude of 1.1. It is unknown if this gradient is representative of the bedrock found in the upland areas due to the unique pebbly-shale lithology, described by WESTON. The gradient at GW-30/GW-31, located near well cluster GW-07/GW-38 but across the East Fork of Mill Creek at the foot of a bedrock hill, is upward with a magnitude of 0.22.

Contrasting hydraulic head relationships in the region are exemplified by clusters GW-07/GW-38 and GW-30/GW-31. The deep well in the first cluster, GW-38, is screened in the bedrock while the shallow well, GW-07, is screened in the unconsolidated sediments. The gradient across the bedrock contact at this location is downward with a magnitude of 0.30, although little actual downward flow may be occurring. The upward gradient across the GW-30/GW-31 pair suggests discharge to the surface, although similarly little upward flow may be taking place.

4.4.4 SURFACE-WATER - GROUND WATER RELATIONSHIPS

Skinner Creek Basin

Several springs were observed along a steep slope below the Trilobite Pond on the east bank of Skinner Creek. This water most likely represents water discharge through the containment wall of the pond. Other springs were observed on the west bank, feeding small tributary streams entering Skinner Creek. These streams appeared to originate from within the glacial deposits. The depth to bedrock at the spring locations is not known.

One of the springs on the west bank of Skinner Creek was the leachate seep sampled during the Phase II investigation. A petroleum-like odor was noted by the sampling technician at LS/LW03. A similar odor was noted when sampling sediments in Diving Pond suggesting the seep may be related to Diving Pond, not Trilobite Pond, as suggested by the site topography.

The flow in Skinner Creek is related to the ground water in the unconsolidated sediments, as reflected in the existence of the springs and in the similar chemistry of the surface water and the ground water sampled from the unconsolidated deposits. On July 29, 1989, during a site visit by WWES, Skinner Creek was reported to be dry, indicating that creek flow and associated ground water discharge are intermittent.

East Fork of Mill Creek Basin

Some direct bedrock discharge into East Fork of Mill Creek occurs along exposures cut by creek erosion across from GW-28 and downstream from GW-30. At these locations, flow was observed to occur along limestone bedding planes, above thicker shale layers. Observations made during March 1990 indicated that the steady outflow of water formed icicles and ice sheets along these planes of preferential flow. The exposed bedrock stood up to 20 feet above the level of the creek and ice was observed along the entire height. These exposures were at the foot of a large bedrock hill on the south side of the creek across from GW-28. This discharge is further evidence of preferential horizontal flow within the bedrock.

Two of the three leachate seeps sampled during the Phase II field work discharged into the East Fork of Mill Creek. These seeps originated within the glacial sediments and indicate that the glacial sediment ground water discharges, at least in part, directly into the creek. Several other springs were observed upstream from the leachate seeps. These springs originated within the glacial deposits and appeared to flow within sandy units above more clay-rich zones.

Leachate produced in the area of GW10/GW09 may utilize the following migration route. Generated by the infiltration of precipitation through the mounded debris and buried waste lagoon, the leachate would likely follow the more permeable units during its migration in both the unsaturated and saturated zones. Downward flow would be deflected horizontally by the silty-clay unit depicted to blanket the bedrock in Figure 3.6. The leachate would follow the upper surface of this less permeable unit until downward flow is possible where the East Fork of Mill Creek is eroding into these sediments. The leachate seep labeled LS/LW02 is located near the point where cross section C-C' intersects the creek (Figure 3.6).

Leachate production at LS/LW-01 may not be related to lithologic controls. This sample location is located directly below a 24" drainage pipe which runs under the gravel road in the direction of the buried lagoon. The original purpose of this pipe is unknown but the pipe is presently draining an orange-colored liquid which is ponded against the north side of the road.

The East Fork of Mill Creek acts as both a recharge source for the underlying bedrock and a discharge point for the glacial deposits at different locations along its course near GW-28 for example. Support for this argument is obtained from the Stiff diagrams discussed in Section 4.4.1. The general water chemistry of Skinner Creek is similar to the glacial deposit ground water confirming the observations of springs discharging into the creek. The ground water chemistry of bedrock wells located adjacent to the creek reflects some mixing from either the glacial deposits or the creek itself, based on the sulfate concentrations. This potential for surface water recharge of bedrock is likely to occur where fractured or highly interbedded bedrock units comprise the creek bed.

4.4.5 Summary of Ground Water Flow Characteristics

The infiltration of precipitation into the glacial sediments provides the majority of ground water recharge at the Skinner site. Ground water flow within the glacial sediments is preferentially through the higher permeability deposits of sand and gravel and along the buried bedrock valleys. Ground water flow within the bedrock is predominantly horizontal along bedding planes and fractures.

The clay tills which commonly overlie the bedrock, combined with the limited vertical permeability of the bedrock, inhibit ground water flow from unconsolidated to bedrock units. Downward vertical hydraulic gradients between the unconsolidated units and the bedrock indicate that the potential exists for ground water from unconsolidated sediments to recharge the bedrock units, but the low vertical permeabilities along this contact limit the significance of this flow path. Variability in hydraulic head relationships and relative permeabilities of creek bed sediments and bedrock complicate a complete definition of ground water discharge/recharge relationships.

SECTION 4

TABLES

Table 4.1
Hydraulic Conductivity Calculation Results
Skinner Landfill – USEPA
K (feet/day)

Phase I Wells	WESTON	WWES	Lithology Screened
GW07	5.42	-	clay, silty, some sand and gravel
GW08	0.920	abandoned	sand, fine, silty, clayey, some gravel
GW09	2.44	0.386	bedrock
GW10	18.7	0.455	clay, sandy, silty, some gravel
GW11	20.6	-	bedrock and clay, sandy, gravelly
GW12	20.1	-	clay, sandy, silty and bedrock
GW14	27.3	-	sand and gravel, silty, some clay
GW15	14.0	0.569	bedrock and clay, silty, sandy
GW15-DP	-	0.454	bedrock and clay, silty, sandy
GW16	7.21	abandoned	sand, silty, gravelly
GW17	1.23	1.17	bedrock (pebbly shale)
GW18	24.0	4.43	bedrock (pebbly shale)
GW19	4.66	-	clay, silty, sandy, gravelly
GW20	16.9	22.7	sand and gravel, crse, grading to fine silty sand
GW21	11.0	abandoned	clay, silty, gravelly, sandy
GW22	19.8	abandoned	clay, silty
GW23	0.760	-	clay, silty, trace gravel
Phase II Wells			
GW24	-	3.46	bedrock
GW26	-	0.0298	bedrock
GW28	-	0.0393	bedrock
GW30	-	0.778	bedrock
GW31	-	5.65	bedrock
GW32	-	0.879	bedrock
GW33	-	15.0	sand, med-crse, gravelly
GW35	-	0.543	bedrock
GW36	-	0.0956	clay, silty, some gravel
GW38	-	0.659	bedrock

Average K for Phase II Testing:

Major Unit Lithology	K
Bedrock	1.46
Clay	0.275
Sand and Gravel	18.8
Sand, Fine, Silty	0.92

Table 4.2
Ground Water Elevations
Skinner Landfill

Well ID	TOC	17-Apr-90 Measured	17-Apr-90 Elevation	18-Apr-90 Measured	18-Apr-90 Elevation	20-Apr-90 Measured	20-Apr-90 Elevation	06-May-90 Measured	06-May-90 Elevation	15-May-90 Measured	15-May-90 Elevation	19-Jul-90 Measured	19-Jul-90 Elevation	07-Feb-91 Measured	07-Feb-91 Elevation
GW06	687.98					11.69	676.29	12.67	675.41	36.75	652.23	OIL		4.11	683.87
GW07	687.74					8.76	678.98			5.39	682.35	9.13	678.61	Could not remove Cap	
GW09	693.21							23.95	669.26	24	669.21	24.05	669.16	23.55	669.66
GW10	690.29							2.09	688.2	2.49	687.8	2.73	687.56	Water in procasing	
GW11	706.09							5.89	700.2	6.15	699.94	7.94	698.15	4.99	701.1
GW12	703.95							5.23	698.72	5.51	698.44	6.66	697.29	Well destroyed	
GW14	746.9							11.24	735.66	12.54	734.36	14.05	732.85	12.68	734.22
GW15	729.58							6.25	723.33	8.18	721.4	12.48	717.1	7.26	722.32
GW17	750.67	25.1	725.57			25.29	725.38	23.97	726.7	24.21	726.46	26.72	723.95	23.35	727.32
GW18	750.42	21.99	728.43			22.22	728.2	20.75	729.67	20.86	729.56	25.97	724.45	20.3	730.12
GW19	734.21							21.2	713.01	20	714.21	23.83	710.38	21.47	712.74
GW20	737.88							41.59	696.29	41.45	696.43	40.72	697.16	40.84	697.04
GW23	769.82							4.16	765.66	4.45	765.37	10.05	759.77	3.6	766.22
GW24	696.12	17.52	678.6	17.56	678.56	17.57	678.55	16.34	679.78	16.88	679.24	18.09	678.03	15.84	680.28
GW25	696.36					DRY		DRY		DRY		Approx. 4" in screen		DRY	
GW26	699.27	29.49	669.78	29.545	669.725	29.56	669.71	29.27	670	29.34	669.93	29.88	669.39	29.13	670.14
GW27	736.73	67.14	669.59	67.485	669.245	67.15	669.58	66.97	669.76	66.91	669.82	67.5	669.23	66.73	670
GW28	688.25			15.9	672.35	15.95	672.3	15.62	672.63	15.58	672.67	16.07	672.18	14.75	673.5
GW29	722.11			25.36	696.75	26.52	695.59	26	696.11	26.04	696.07	27.42	694.69	25.94	696.17
GW30	678.62	10.95	667.67	11.155	667.465	10.95	667.67	10.66	667.96	10.69	667.93	10.46	668.16	10.01	668.61
GW31	677.59					11.68	665.91	11.57	666.02	11.49	666.1	11.11	666.48	10.53	667.06
GW32	673.02	5.54	667.48	5.59	667.43	5.58	667.44	5.51	667.51	5.46	667.56	6.13	666.89	5.18	667.84
GW33	672.74					4.83	667.91	4.68	668.06	4.73	668.01	5.19	667.55	4.62	668.12
GW35	671.98	4.39	667.59	4.45	667.53	4.45	667.53	4.44	667.54	4.4	667.58	4.65	667.33	4.12	667.86
GW36	671.84					4.84	667	4.64	667.2	4.71	667.13	5.28	666.56	4.47	667.37
GW38	684.5	15.69	668.81	15.785	668.715	15.75	668.75			15.59	668.91	15.57	668.93	14.89	669.61
BO05	731.09							11.46	719.63	8.36	722.73	11.74	719.35	9.82	721.27
BO08	732.35							9.36	722.99	10.88	721.47	12.33	720.02	11.78	720.57

Table 4.3
Vertical Gradients in
Clustered Wells
Skinner Landfill

Well ID							
Recharge Zones	Screened in:	17-Apr-90	20-Apr-90	06-May-90	15-May-90	19-Jul-90	Average Gradient
GW07	UN		+0.28		+0.37	+0.26	+ 0.30
GW38	BR						
GW10	UN			+1.12	+1.10	+1.09	+ 1.10
GW09	BR						
GW18	BR	+0.16	+0.16	+0.16	+0.17	+0.18	+ 0.14
GW17	BR						
BO05	UN			+0.68	+0.88	+0.92	+ 0.83
GW19	UN						
GW20	UN			+1.27	+1.27	+1.33	+ 1.29
GW27	BR						
GW33	UN		+0.02	+0.02	+0.01	+0.02	+ 0.02
GW32	BR						
Discharge Zones							
GW31	BR		−0.21	−0.23	−0.22	−0.20	− 0.22
GW30	BR						
GW36	UN		−0.02	−0.01	−0.02	−0.03	− 0.02
GW35	BR						

BR – Bedrock — – – Upward Gradient
UN – Unconsolidated — + – Downward Gradient

SECTION 4

FIGURES

Figure 4.1 Stiff Diagrams

Unconsolidated Deposits

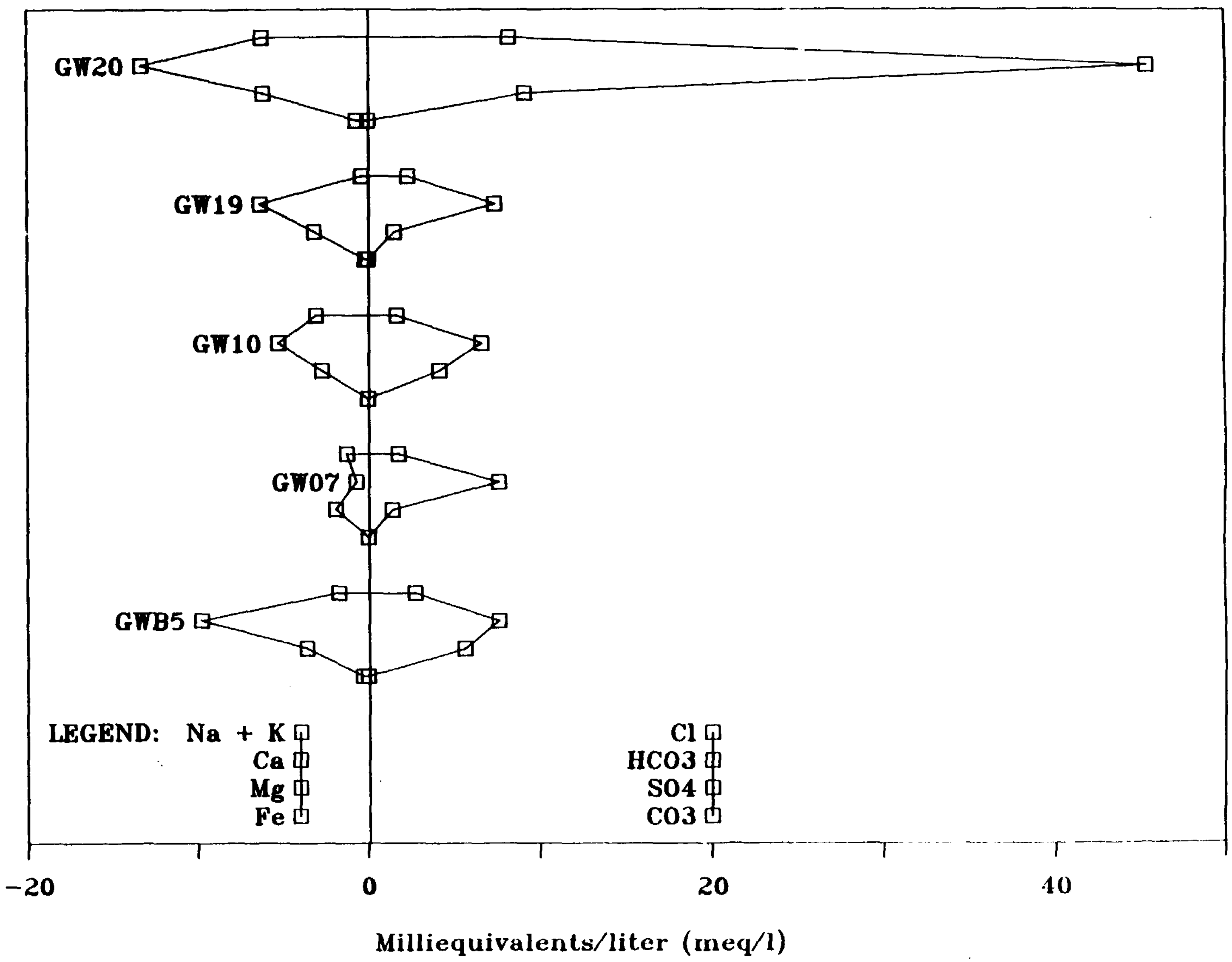


Figure 4.2 Stiff Diagrams

Bedrock Ground Water

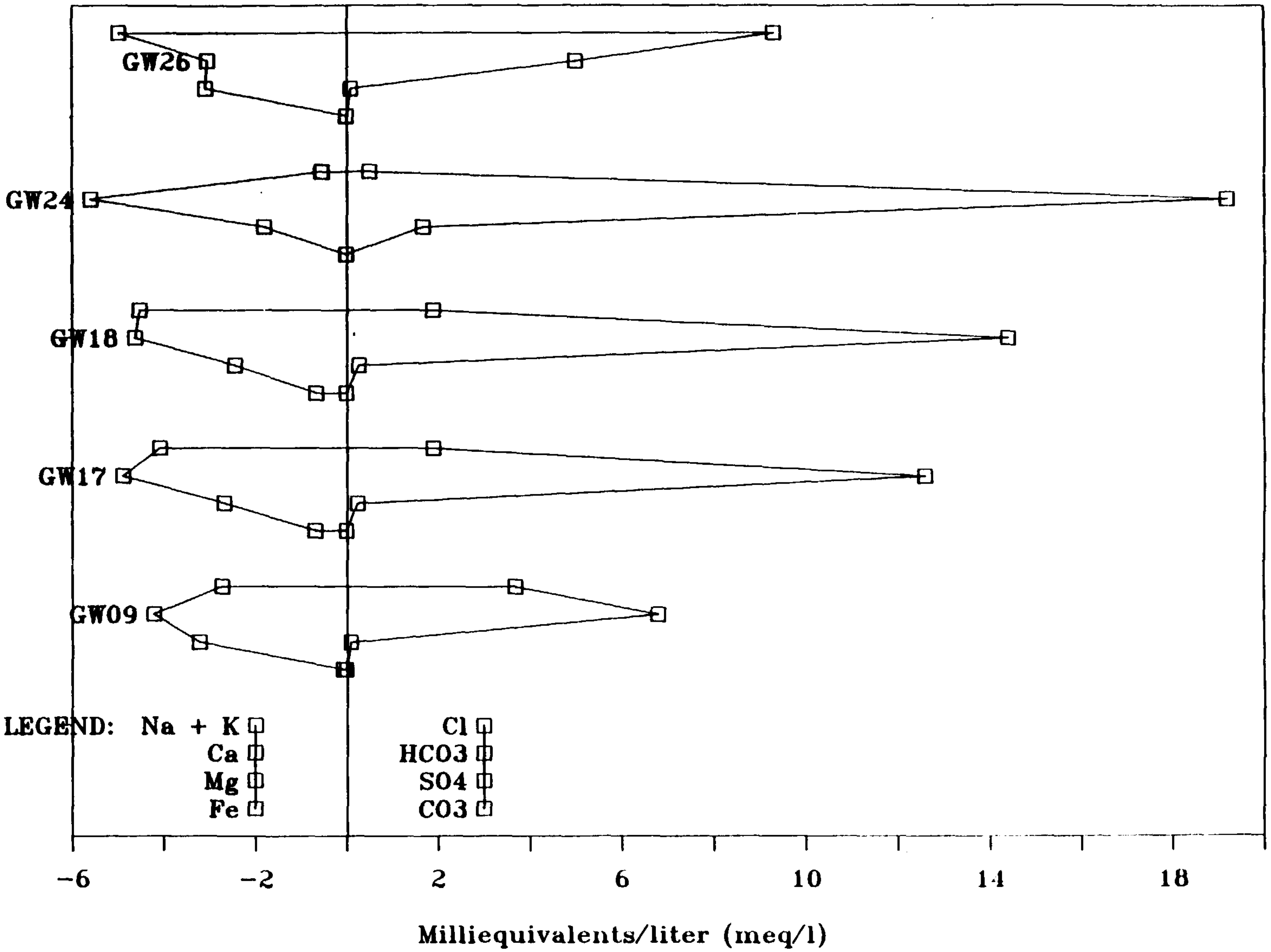


Figure 4.3 Stiff Diagrams

Bedrock Ground Water

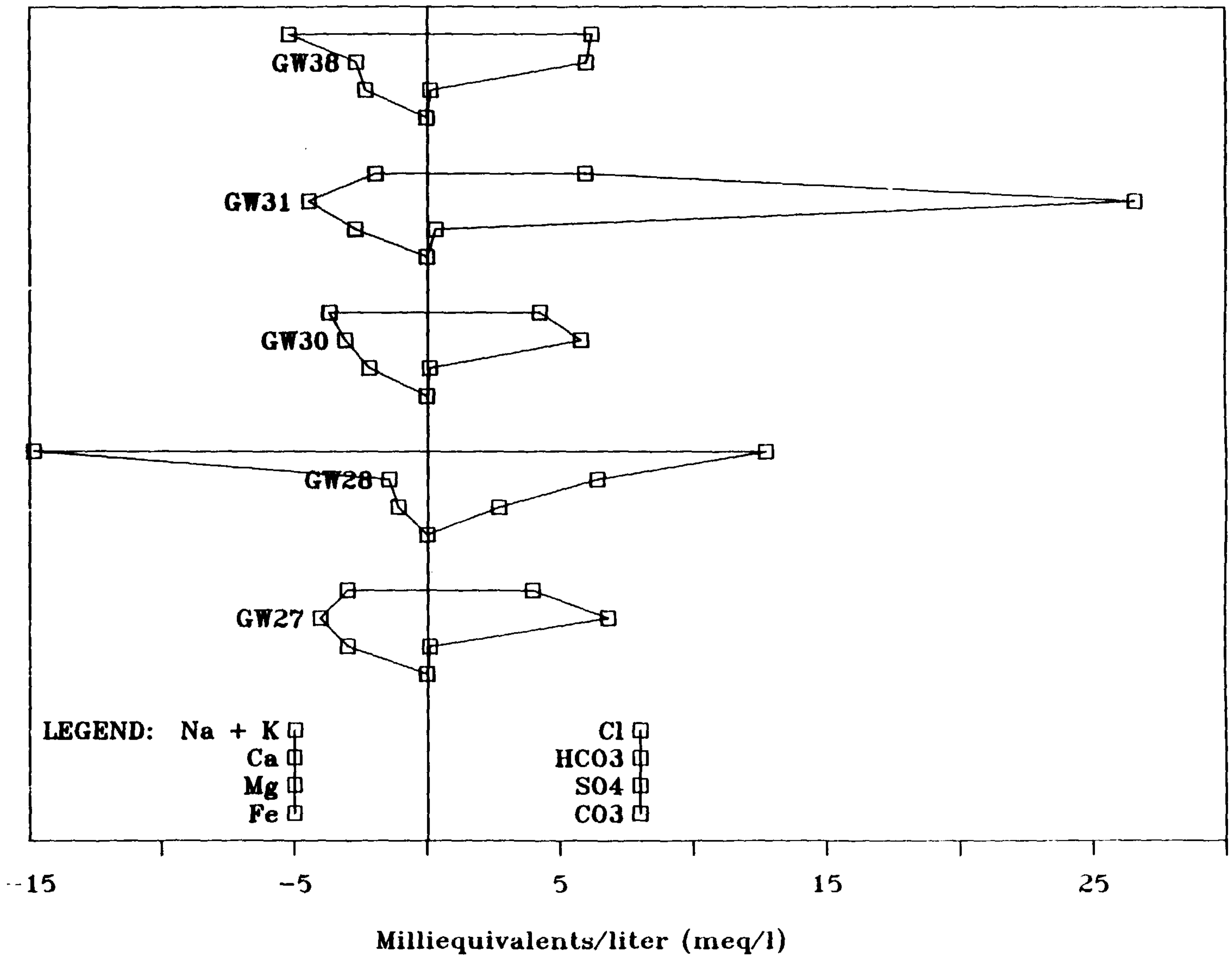


Figure 4.4 Stiff Diagrams

Wells Straddling The Contact

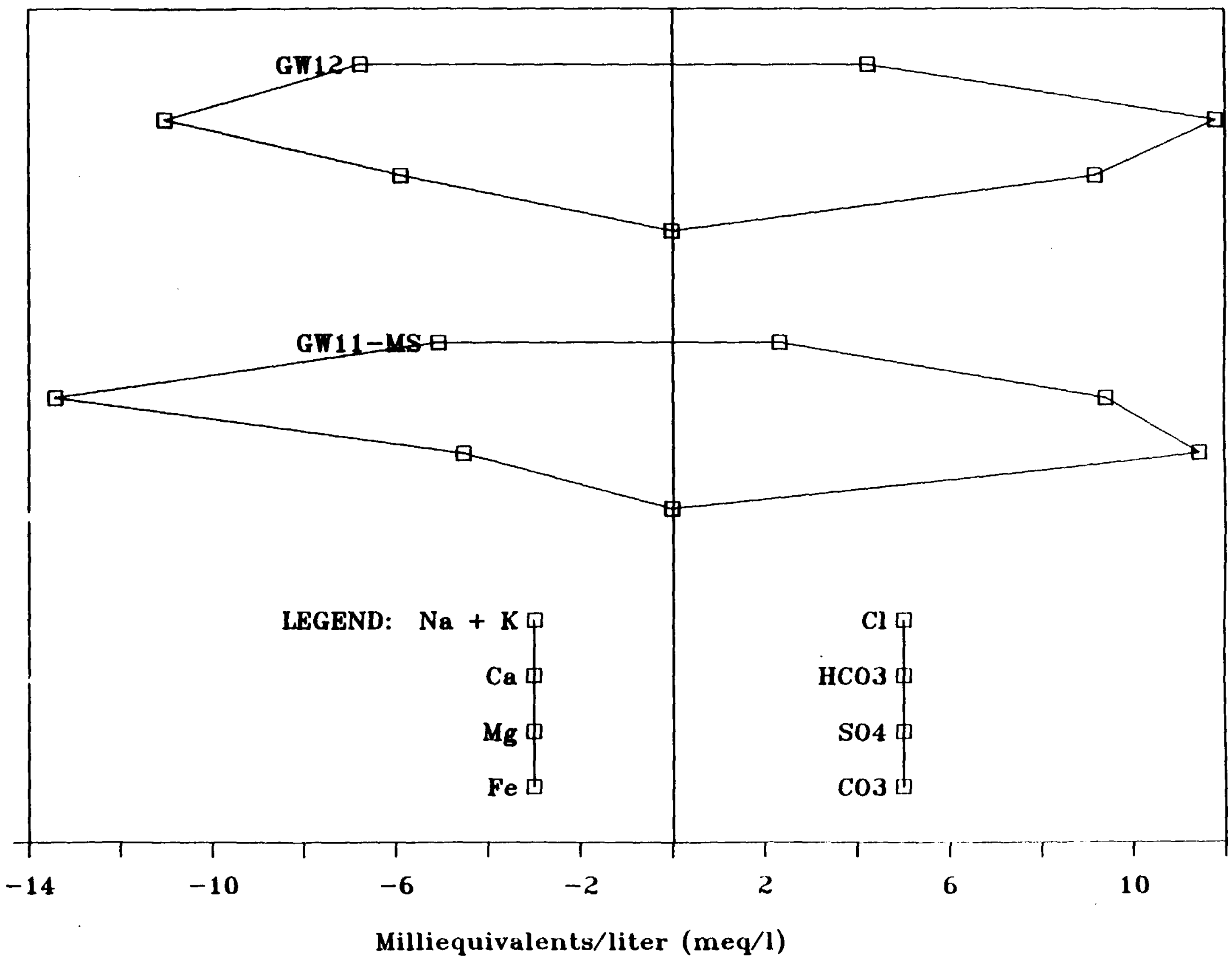


Figure 4.5 Stiff Diagrams

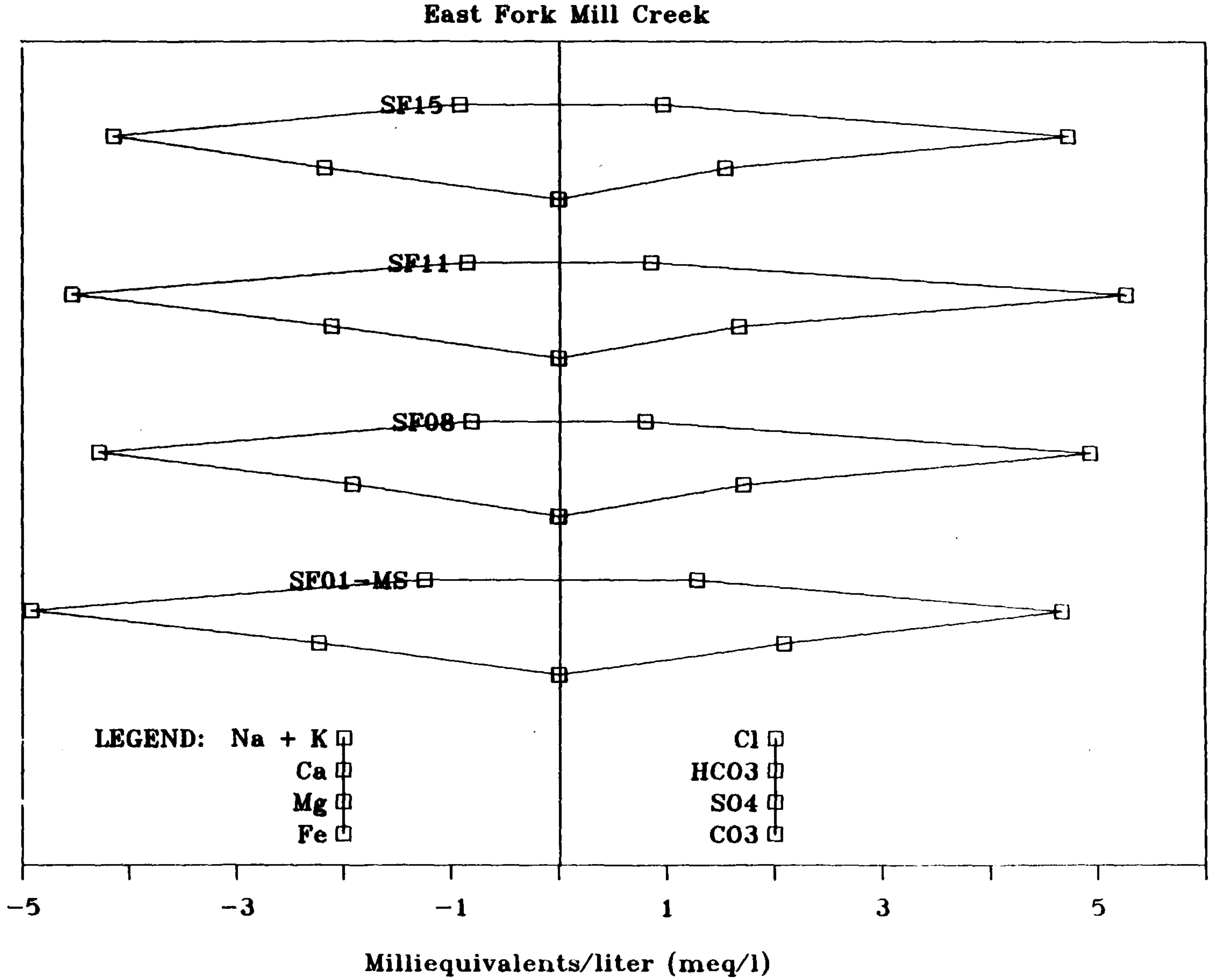


Figure 4.6 Stiff Diagrams

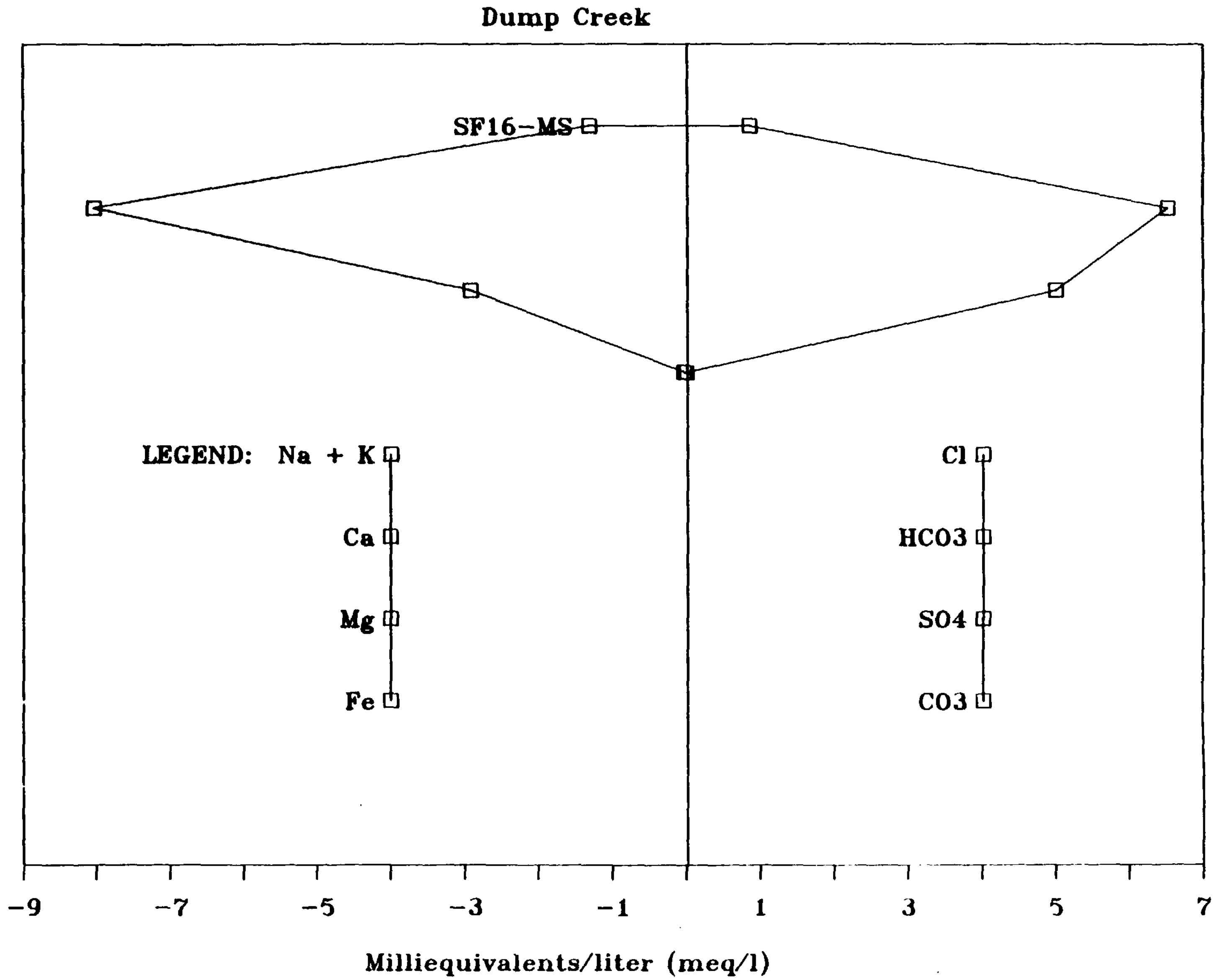


Figure 4.7 Stiff Diagrams

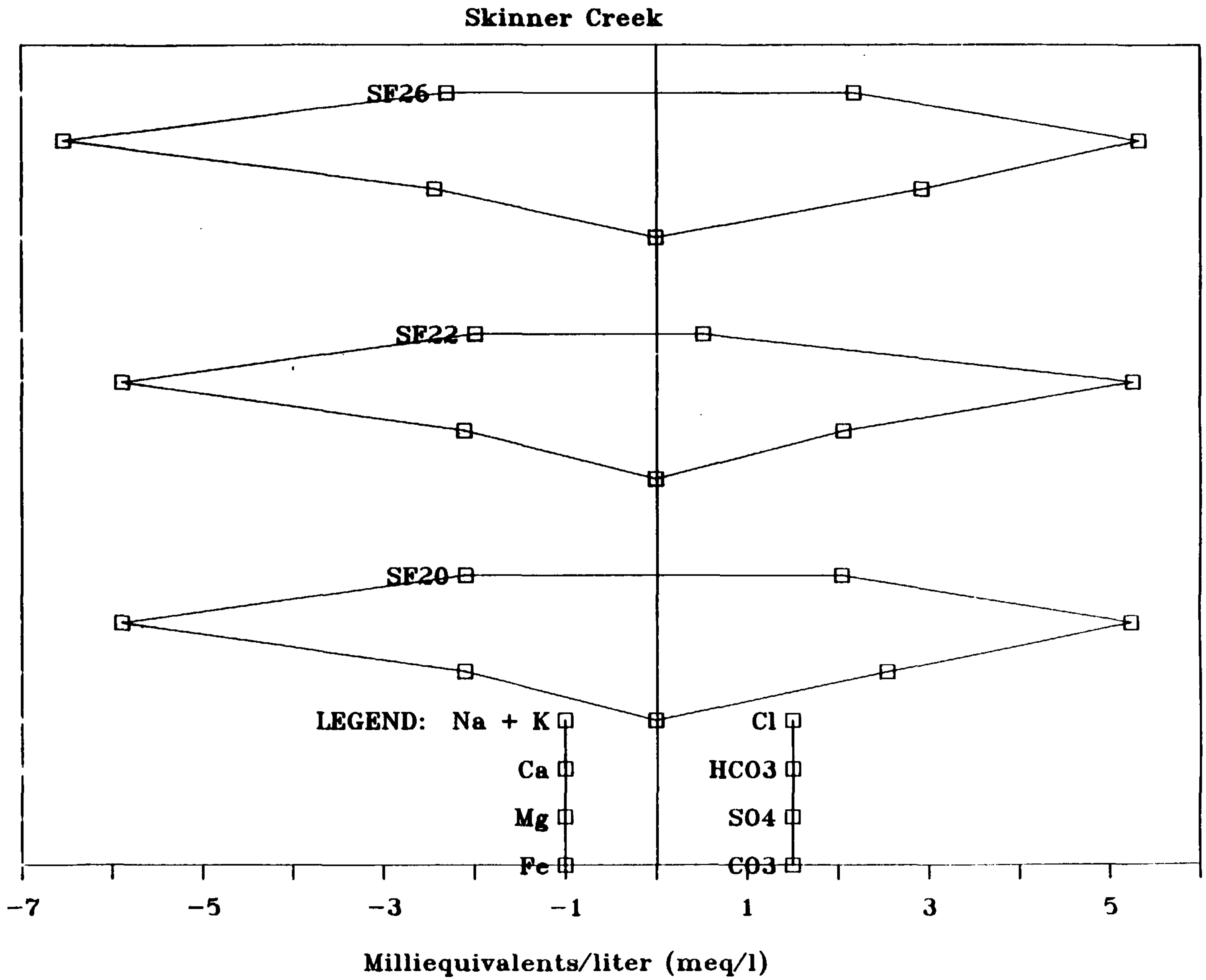
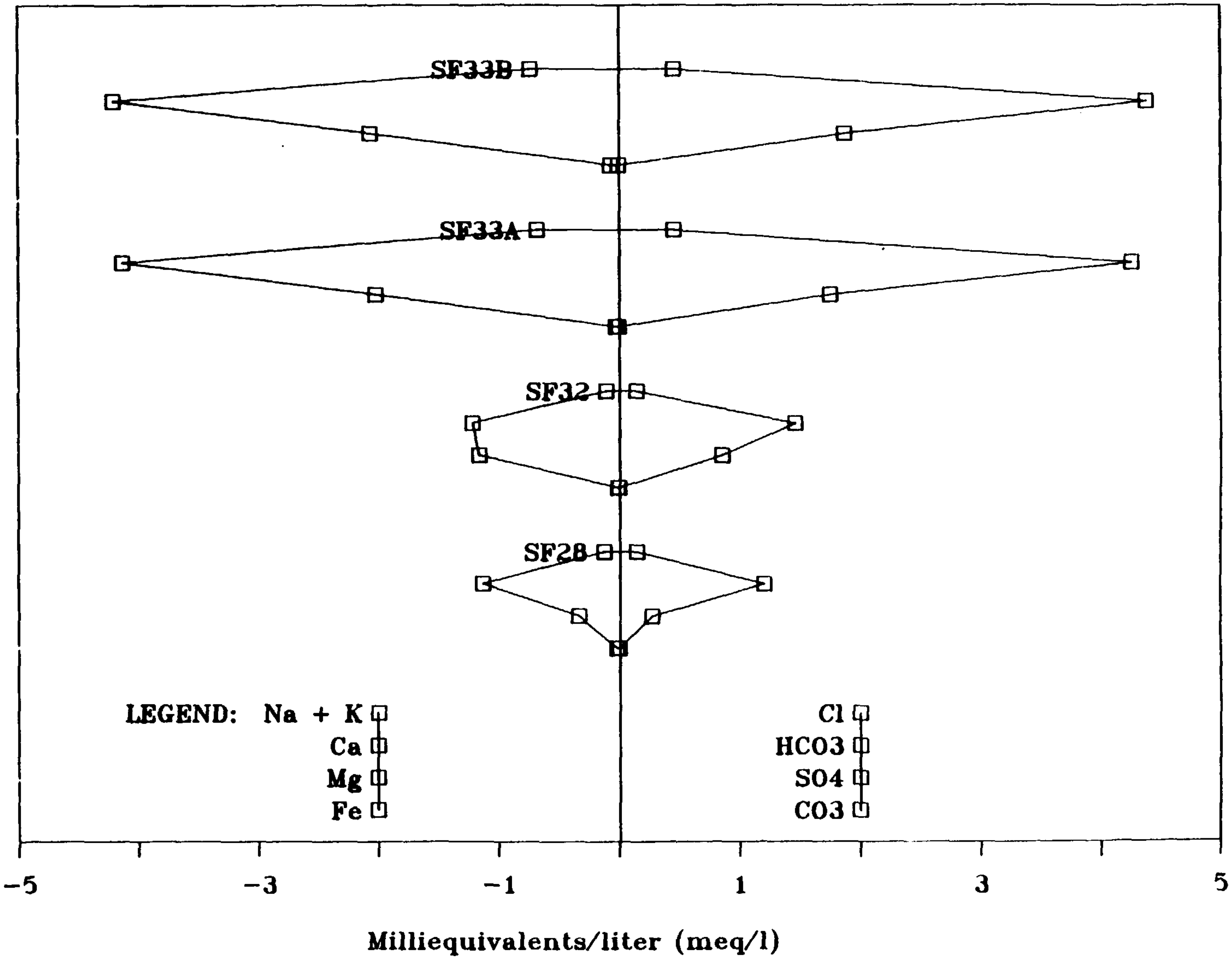
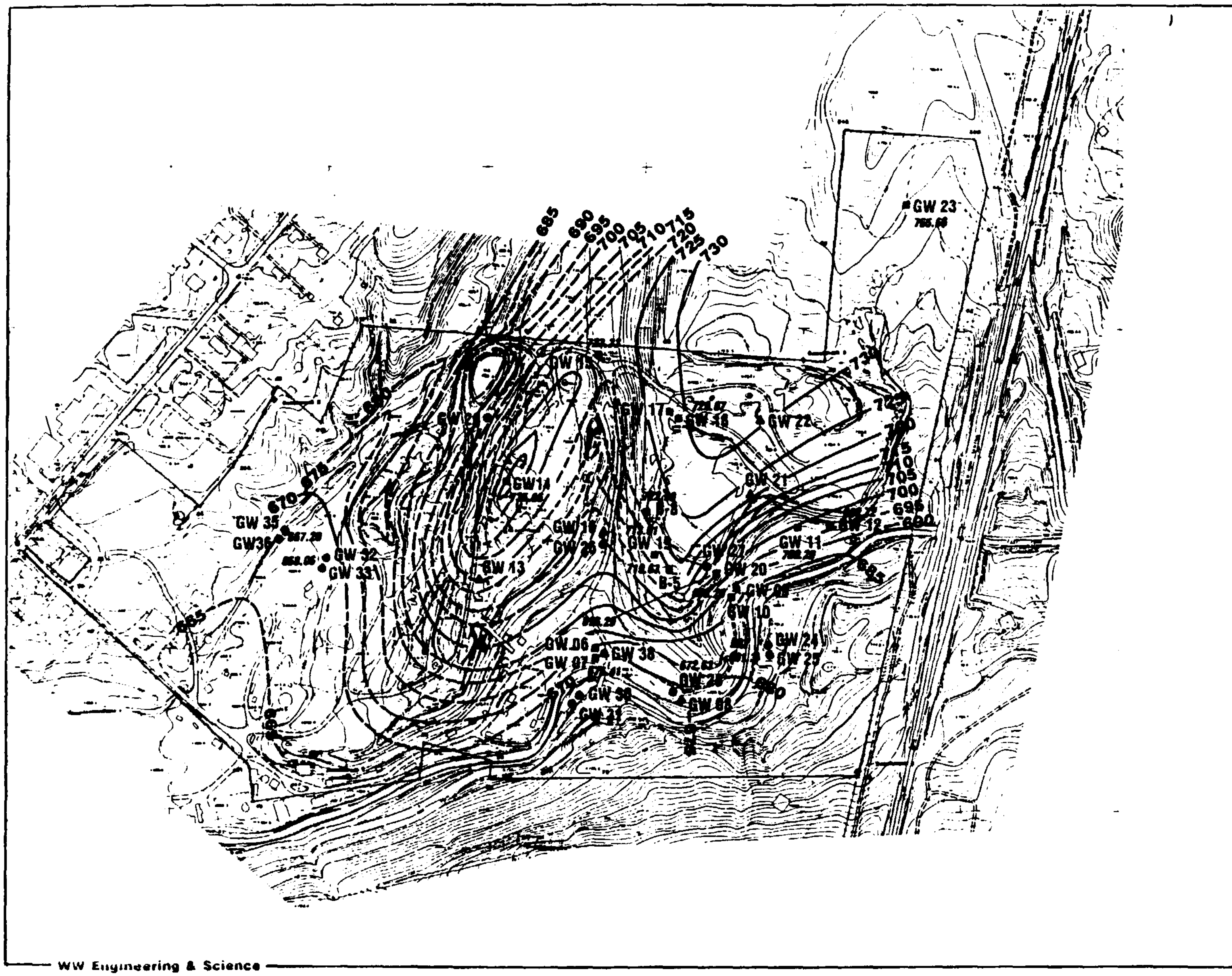


Figure 4.8 Stiff Diagrams

Duck, Diving and Trilobite Ponds





LEGEND

- ● Monitoring Well (Phase II)
- ■ Monitoring Well (pre-Phase II)
- ▲ Abandoned Monitoring Well

NOTE:

1. Elevation of pond water inferred from site survey. (Revised 6-14-90)
   Trilobite Pond: 682.1
   Diving Pond: 696.6
2. Contours are based upon water levels in existing unconsolidated sediment wells. Also included are bedrock wells GW 18 and GW 28 which are located where the water table drops into the bedrock. The remaining bedrock wells do not have the water elevations indicated.

N

0 150 300 600

Scale in Feet

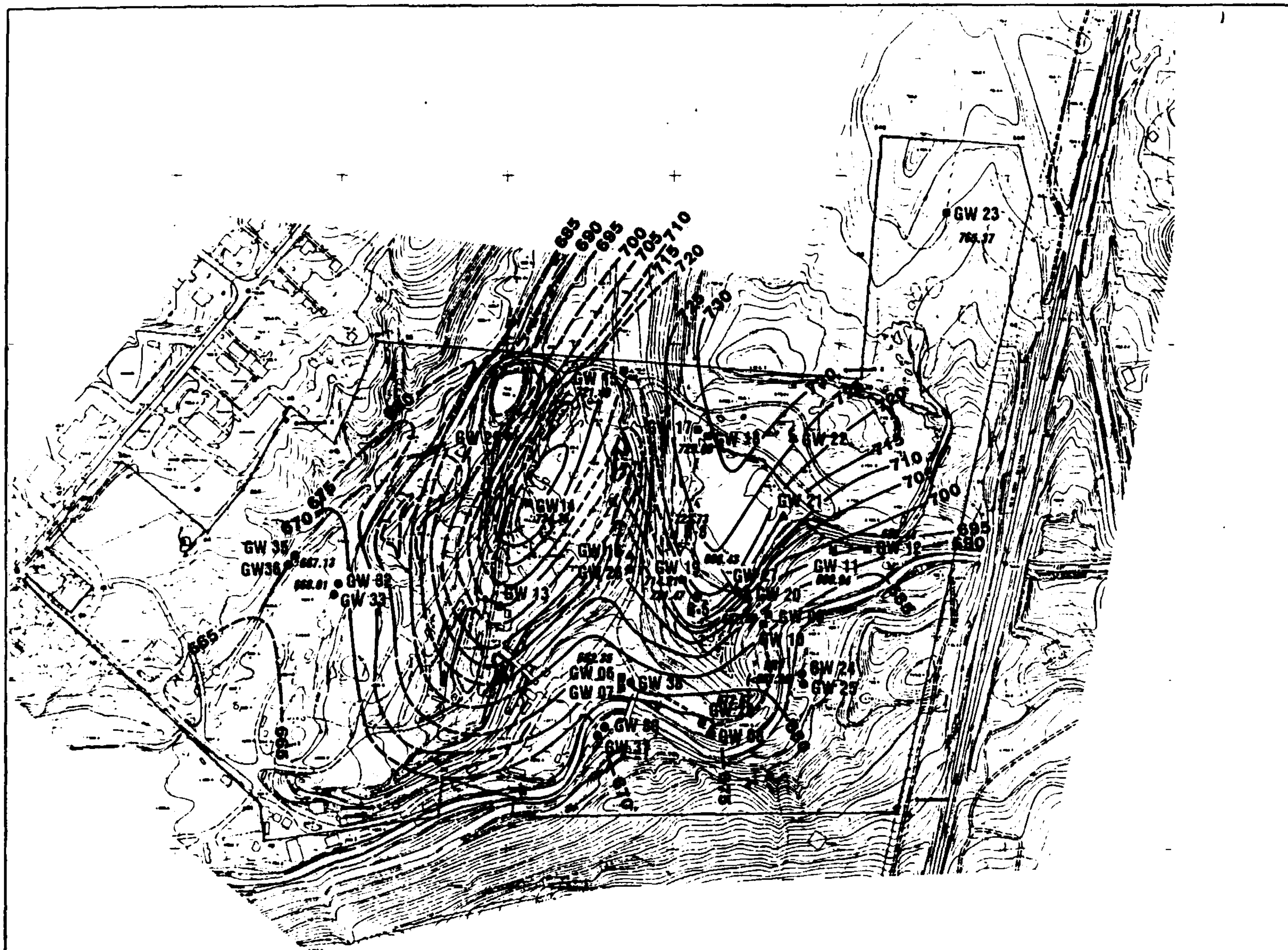
Figure 4.9

WATER LEVEL CONTOUR MAP FOR MAY 6, 1990

Skinner Landfill

West Chester, Ohio

February, 1991 04003.14



LEGEND

- ● Monitoring Well (Phase II)
- ■ Monitoring Well (pre-Phase II)
- ▲ Abandoned Monitoring Well

NOTE:

1. Elevation of pond water inferred from site survey. (Revised 6-14-90)
   Trilobite Pond: 682.1
   Diving Pond: 696.6
2. Contours are based upon water levels in existing unconsolidated sediment wells. Also included are bedrock wells GW 18 and GW 28 which are located where the water table drops into the bedrock. The remaining bedrock wells do not have the water elevations indicated.

N

0 150 300 600
Scale in Feet

Figure 4.10

WATER LEVEL CONTOUR MAP FOR MAY 15, 1990

Skinner Landfill
West Chester, Ohio

February, 1991 04003.14

WW Engineering & Science

5.0 SOIL AND WATER CHEMISTRY

This section discusses the results of the chemical analyses of soil samples collected from soil borings, ground water samples obtained from the monitoring wells and sediment and surface water samples taken from the ponds, creeks and leachate seepage points. The motivations and criteria for sampling each location and matrix are also briefly described. Appendix B presents a summary of the number and type of samples taken during the Phase II investigation.

In April of 1976 a report to the Ohio Environmental Protection Agency (OEPA) of a black, oily liquid in a waste lagoon on the Skinner Landfill prompted the initiation of a site investigation. Aerial photos taken in 1976 indicated a lagoon, several ponds, and piles of drums to be present on the Skinner site. Analysis of sludge from the buried lagoon and of drum liquids revealed pesticides, including chlordane intermediates, some volatile organic compounds and heavy metals.

As described in previous investigations, the waste lagoon and adjacent areas are the source for the majority of the contamination encountered on the Skinner site. The lagoon is buried under up to 20 feet of apparent demolition debris. Figure 3.13 illustrates the lagoon's probable extent, based upon the Phase II waste lagoon boring program.

5.1 SAMPLE ANALYSIS/VALIDATION

The Quality Assurance Project Plan (QAPP) Addendum (September 28, 1989) specified all sample collection, handling and shipping methods. These were conscientiously followed to provide for meeting the required quality criteria for developing defensible data. In the case of the waste lagoon exploration, the decontamination procedures were modified to be more stringent than stated in the QAPP. The QAPP Addendum also referenced in detail all analytical methods for CLP and non-CLP laboratory analyses that were used for the Skinner Landfill samples. Any deviations from the QAPP were discussed in Section 2.0 of this document and in the task-specific technical memoranda.

Chemical data validation included an independent review and quality assessment of the analytical methods performed on the samples. This review was performed by the Central Regional Laboratory (CRL). WWES laboratory staff summarized the CRL quality assurance laboratory reviews in a form intended to be more "user-friendly." These summaries were used by WWES staff during the data review, database development, and the preparation of this RI report.

Additional reviews were performed in the field to evaluate the quality of the investigative methods and documentation procedures. These field reviews were performed by an experienced WWES professional, acting as site manager, who was familiar with the field procedures proposed for the Phase II investigation.

The raw data upon which this section and the Summary Tables are based is presented in Appendix B. This Appendix provides a discussion of the qualifiers used to report the analytical data, a sample identification key and the raw data, in tabular form, broken down into the sample type, matrix and analytical scan. For the soil samples, the sampled intervals are indicated prior to the data presentation in Appendix B.

5.2 SITE SOILS

As part of the Phase II RI, a total of twenty-two soil borings were installed within two general areas of the Skinner Landfill site: at the buried pit and adjacent to and within the former waste lagoon. In addition, soil samples were collected for analysis from three hand auger borings, located near the property line north of the active landfill, and from six monitor well boreholes. Sample intervals are indicated in Table 5.1.

The analysis of the soils sampled from the Skinner site are presented in Appendix B. Summary tables of analytical results were prepared for clarity and brevity. Table numbers are indicated in the appropriate sections. These tables indicate the number of detections for each compound and the ranges of detection. These tabulations take into account the effect of blank contaminants as follows: if a compound was detected in an investigative sample at greater than or equal to 10 times the amount found in an associated blank sample, the detection was considered valid. If the detected amount was less than 10 times the blank concentration, the detection was considered invalid. Duplicates and resampled locations are included in the summary tables. Background detection values, represented by the GW-35 sample set, are presented for comparison in each table.

5.2.1 SITE SOIL SAMPLE BLANK CONTAMINATION

The following sample blanks were taken as part of the quality control program in place during the Phase II drilling program: 26 atmospheric blanks (AB), 9 field blanks (FB) and 1 trip blank (TB). Atmospheric blanks were analyzed only for volatile organic compounds and were composed of deionized water poured into a sample container during the field investigation. Field blanks consisted of silica sand poured through sampling equipment into sample jars. The trip blank was collected at the field trailer and consisted of deionized water. The trip blank accompanied the investigative sample containers in the field and through shipping to the laboratory. Field blanks were analyzed for all parameters while the trip blank was analyzed only for volatile organic compounds.

Silica sand was used for the preparation of the soil field blanks. Two series of silica sand samples were sent for analysis to determine the level, if any, of contamination present in the sand before its use on the Skinner site. The first series of sand samples were sent on February 6 and 7, 1990. The analysis of these samples revealed 0.009 mg/kg of acetone and 0.003 mg/kg of methylene chloride. The second series of silica sand samples was sent for analysis between April 2 and April 7, 1990. This series of samples contained 0.17 mg/kg of diethyl phthalate and 0.03 mg/kg of methylene chloride. The detection of these compounds in these samples probably represents laboratory contamination.

Table 5.2 lists the contaminants detected in the sample blanks and the associated detection ranges. The VOC contamination detected within the atmospheric blanks may have three sources: degradation of the air quality during the construction of the borings, laboratory introduced contamination or the possible contamination of the source water with which the blank vials were filled. The detection of common laboratory contaminants such as acetone, chloroform and methylene chloride seems to support laboratory introduction. Toluene and 1,1,1-trichloroethane were seen in only a slightly lesser number of blanks. These compounds were detected in many of the field blanks associated with the waste lagoon borings. Toluene was found in significant concentrations within waste lagoon borings and methylene chloride was found in significant concentrations during the soil gas survey.

With the exception of diethylphthalate, each of the seven semi-volatile compounds detected in the field blank samples was detected in only one of the blank samples. Because these semi-volatile compounds were also detected in investigative samples, they may reflect residual contamination of the sampling equipment. The detection of diethylphthalate in three field blank samples is attributable to either laboratory contamination or contamination of the silica sand source, as the second and independent source of sand used in the preparation of blanks had detectable levels of this compound. The detection of pesticides, dioxins and furans may represent sampling equipment contamination, which, despite conscientious adherence to the decontamination protocol, may have passed from the sampling equipment to the investigative sample.

5.2.2 Buried Waste Lagoon Area Soils

The buried lagoon located south of the active landfill has not been sampled since 1976 nor has the lateral and vertical extent of waste in the lagoon ever been definitively determined.

Twenty-four soil borings were completed in and around the buried waste lagoon. A total of 65 soil samples were collected for analysis. These soil samples were collected from the WL and BL series and from GW-27. Intervals sampled during the construction of these borings are indicated in Table 5.1. Boring locations are shown on Figure 5.6.

Waste Lagoon Borings (WL)

Waste lagoon borings were drilled in 16 locations to determine the lagoon's areal extent and to sample its contents.

Section 2.3.2 describes the drilling methods associated with defining the buried waste lagoon. Split spoon soil samples were collected from the top of the buried lagoon and continued until the soil no longer appeared contaminated. All drilling and sampling was monitored with an Hnu or equivalent instrument. A maximum of three samples per auger boring were collected for chemical analysis: all samples that had odors, discolorations, an oily sheen or Hnu readings above the ambient level were retained. The lagoon samples were analyzed for RAS organics, RAS inorganics and additional SAS parameters. A total of 42 soil samples were collected from the waste lagoon borings.

Buried Lagoon Borings (BL)

Three additional borings, the BL series, were drilled around the perimeter of the buried lagoon to gain better spatial definition of potential contamination in the adjacent soils. With the exception of the sampling intervals, the drilling method was identical to that of the previously described waste lagoon borings. Split spoon samples were collected from the soil borings at depths of 2.5, 5, 7.5 and 10 feet and at 5 foot intervals thereafter until the water table was encountered. A maximum of 5 and a minimum of 1 soil sample were collected for chemical analysis in the unsaturated zone. If no split spoon sample failed the "meter, odor, visual" test, then the sample obtained directly at the water table was selected for chemical analysis. The soil samples were analyzed for RAS organics, RAS inorganics and SAS constituents including additional pesticides, TOC, and dioxin. A total of 16 soil samples were taken from the buried lagoon borings.

Monitoring Well Boring (GW-27)

One soil boring (GW-27) was drilled and converted to a monitoring well in the vicinity of the buried waste lagoon. Seven soil samples from that boring were analyzed for the same parameters as the buried lagoon (BL) samples.

5.2.2.1 Field Screening of Waste Lagoon Area Soil Samples

The borings which penetrated the waste lagoon encountered debris described as wood, plastic, metal, brick, wire, glass, paper and rubber. Below the mounded debris, several borings (WL-05, WL-09 and WL-14) encountered a tar-like material and oily sediments, possibly related to the sludge sampled by the OEPA in 1976. Also encountered were sticky liquids described as raspberry and turquoise in color (WL-07 and WL-10). These materials, found above the natural soils, have a distribution which roughly follows the depression shown in Figure 3.13.

Elevated OVA and/or Hnu readings, over 10,000 ppm in some soil samples, correspond with the transition from debris to lagoonal materials and extend into the underlying natural soils. These readings are recorded on the well and boring logs included in Appendix B and their distributions are indicated on cross sections B-B' through G-G', Figure 5.1 through 5.5. The surface traces of these cross sections may be seen on Figures 3.2 and 3.3.

As discussed in Section 4.4.3.1, the elevated organic vapor readings extend into the saturated soils described on the drilling logs. Less permeable sediments appear to resist the downward migration of the volatile compounds detected with the field screening devices. The distribution of elevated readings plotted on Figure 5.1 demonstrates possible migration patterns from the waste lagoon. The elevated readings follow the upper surface of the silty clay unit and extend across GW-27 to BL-01. Infiltrating water may follow a similar migration pathway. The highest soil vapor reading observed in BL-01 occurs immediately above the water table, as interpreted from GW-20, below a clayey unit and within a sandy gravel. No detectable levels of organic vapors were observed in soil samples from GW-28.

The distribution of elevated organic vapors illustrated in Figure 5.2 follows a pattern similar to those of Figure 5.1. The highest values are seen within WL-14 in sediments described as silty, gravelly sand and the lowest values within a unit composed of clay with some gravel.

Figures 5.3, 5.4 and 5.5 reveal distributions comparable to those illustrated in the previous figures. In general, the organic compounds detected by the field screening are moving preferentially through the more permeable sediment units, following both the water table and the upper surfaces of less permeable deposits. The vapor levels tend to decrease with depth.

5.2.2.2 Laboratory Analysis of Buried Waste Lagoon Area Soil Samples (WL, BL, and GW-27)

The results of the analysis of the soil samples obtained from the waste lagoon area soil borings are discussed in the following sections. A summary table of the laboratory results is presented as Table 5.3. The indicated background values represent the GW-35 soil sample set. The risk assessment document will present a statistical analysis of the Phase II analytical results, incorporating chemical data from the Phase I investigation. The locations of the borings are shown in Figure 5.6.

The volatile organic compound analysis of the soil samples from the buried waste lagoon area revealed widespread detections. The most common compounds encountered and their maximum concentrations are as follows, ordered by decreasing frequency: toluene (31,000 mg/kg); xylene (200 mg/kg); ethylbenzene (98 mg/kg); 1,1,2-trichloroethane (370 mg/kg); 1,2-dichloropropane (340 mg/kg); and benzene (60 mg/kg). Also significant, based upon the maximum concentrations, are acetone (140 mg/kg), carbon tetrachloride (160 mg/kg) and 1,1,2,2-tetrachloroethane (130 mg/kg). In general, the highest total volatile organic compound concentrations encountered correspond with the stained and disturbed soils described on the boring logs (Appendix A) and the elevated vapor readings displayed on Figures 5.1 through 5.5. Toluene appears to be the major volatile organic compound component of the various colored liquids encountered in borings WL-07 and WL-10. The noted compounds were not detected in the background samples.

The semi-volatile organic compounds reveal a spatial distribution similar to that of the volatile organic compounds. The most common compounds, ordered by decreasing frequency and with the maximum concentrations noted, are as follows: napthalene (610 mg/kg); 2-methylnaphthalene (220 mg/kg); phenanthrene (110 mg/kg); bis(2-ethylhexyl)phthalate (150 mg/kg); benzoic acid (1100 mg/kg); fluoranthene (110 mg/kg); pyrene (48 mg/kg); hexachlorobenzene (480 mg/kg); fluorene (34 mg/kg); phenol (26 mg/kg); butylbenzylphthalate (25 mg/kg); 1,3-dichlorobenzene (230 mg/kg); 1,4-

dichlorobenzene (180 mg/kg); hexachlorobutadiene (68 mg/kg); acenapthene (7.9 mg/kg); benzo(a)anthracene (15 mg/kg); chrysene (17

mg/kg); and hexachlorocyclopentadiene (1100 mg/kg). The semi-volatile compound distribution also corresponds with the impacted soils described on the boring logs. The background samples contained di-n-butylphthalate (0.073 mg/kg) and bis(2-ethylhexyl)phthalate (0.091 mg/kg).

The major semi-volatile compound components of the oily black liquid and the black tar-like substance are hexachlorocyclopentadiene, hexachlorobenzene, naphthalene and 2-methylnaphthalene. The black tar-like substance also contains significant amounts of benzoic acid. The blue and raspberry colored liquids usually contain lesser amounts of semi-volatile compounds and their composition is dominated by naphthalene, 2-methylnaphthalene, phenanthrene and bis(2-ethylhexyl)phthalate.

The most common pesticide detected in the analysis of the waste lagoon area soil samples was heptachlor with a maximum concentration of 52 mg/kg in WL-05BMS. WL-05BMS also contained the highest concentration of endrin ketone (84 mg/kg) and gamma-chlordane (44 mg/kg). These compounds were detected in WL-09B and WL-15B in large concentrations. WL-15A contained PCB Aroclor 1248 (0.78 mg/kg) and Aroclor 1260 (1.2 mg/kg). Pesticide and PCB detections correlated with the previously mentioned soil staining.

The following compounds, detected by the alternate pesticide scan, also included in the semi-volatile compound analysis scan, were detected in a greater number of samples due to the lower detection limits achieved by the alternate pesticide scan. These compounds, detected in high concentrations in WL-14B, are hexachlorobenzene (1800 mg/kg), hexachlorocyclopentadiene (4300 mg/kg) and hexachlorobutadiene (260 mg/kg). WL-14B also contained the highest concentrations of octachlorocyclopentene (23,000 mg/kg), chlordene (1200 mg/kg) and 1,2,3,4,5,7,7-heptachlornorborene (2500 mg/kg). These compounds were included in the alternate pesticide scan. This sample corresponds with the black, oily tar described on the boring log.

Significant inorganic compound detections occurred in the buried waste lagoon area. The following metals were encountered at concentrations considerably above those detected in the background samples: aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, sodium, thallium and zinc. Cyanide was detected in WL-07A, BL-02B and BL-02G with a maximum concentration of 43.6 mg/kg detected in WL-10AMS. The mercury detections occurred in WL-13A and WL-13B with the highest concentration, 5.3 mg/kg, found in WL-09B. The risk assessment will include a statistical analysis of the inorganic compound detections.

The analysis for dioxins and furans indicated tetra CDF and penta CDF to be the most frequent compounds detected. Twelve dioxins and furans were detected in the waste lagoon area soil samples. These compounds are listed in Table 5.3. WL-05B contained the highest concentrations of most compounds, followed by BL-03A, WL-07D and WL-10AMS. WL-09B and WL-09BRE also contained elevated compound concentration levels. A complete statistical analysis of these data will be provided in the risk assessment.

Initial estimates were made of areas and volumes of debris and impacted soils in the buried waste lagoon area. These estimates were based upon the drilling log descriptions and thicknesses and the distances determined during the site survey. The Feasibility Study, to be completed in 1991, will provide greater accuracy and confidence in these determinations.

The debris overlying the waste lagoon area had an estimated area of 8.8×10^4 ft^2 and an estimated volume of 1.6×10^6 ft^3. Visually impacted soils below the debris have an approximate area of 1.5×10^4 ft^2 and an estimated volume of 1.2×10^5 ft^3. Impacted soils, as determined by field screening of soil samples using organic vapor analyzers, had an estimated volume of 2.9×10^6 ft^3, including the visually impacted soils and a small portion of the overlying debris.

5.2.3 Buried Pit Soils (BP)

In addition to the buried waste lagoon, one other potential contaminant source area on the Skinner site has been identified. This second area, the buried pit, was identified on old aerial photographs as a "waste pond." This "waste pond" has subsequently been filled in. Exploration of this area was necessary to determine if it was ever impacted by disposal operation at the Skinner Landfill and to access the potential for residual contamination in the soils.

Three soil borings were drilled into the pit and are identified as the BP series. The construction of these borings was discussed in Section 2.3.1 and their locations are indicated on Figure 5.7. Sampled intervals are shown in Table 5.1. The soil samples were analyzed for RAS organics, RAS inorganics and SAS constituents including additional pesticides and TOC.

A total of 6 soil samples were collected from the buried pit borings.

5.2.3.1 Field Screening of Buried Pit Soil Samples

Of the three borings completed at the buried pit location, two did not reveal soil staining or elevated Hnu readings. The third boring, BP-02, contained soils with organic vapor concentrations up to 25 ppm in the 3.5 foot to 5.0 foot sample interval (sample B.) In addition, the sample from 6.0 feet to 7.5 feet (sample C) contained black discoloration. The delineation of the former location of the buried pit shown on Figure 3.10 was defined from the recorded descriptions of fill on the drilling logs. In general, this was limited to gravel and sand with some silt and clay with occasional wood fragments.

5.2.3.2 Laboratory Analysis of Buried Pit Samples (BP)

The results of the analysis of the soil samples obtained from the buried pit borings are discussed in the following sections. A summary table of the laboratory results is presented as Table 5.4. The indicated background values represent the GW-35 soil sample set. The risk assessment document will present a statistical analysis of the Phase II analytical results which also incorporate chemical data from the Phase I investigation.

Volatile organic compounds were detected in soil samples obtained from BP-02 and BP-03. Toluene was encountered in all samples from these borings but the concentration range lies below that of the background sample site. However, BP-02A, BP-02B and BP03A contained ethylbenzene and xylene (total) at concentrations greater than the background samples. Two other compounds were detected above the background levels: acetone in BP-02A and chloroform in BP-02C.

The majority of the semi-volatile compounds detected were encountered in BP-01A, BP-02A and BP-02C. The concentration ranges overlap in some cases with those of the background samples. The following chemicals had detection ranges above the background ranges: phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, bis(2-ethylhexyl)phthalate and benzo(a)pyrene. Other detections above background were encountered as follows: 4-methylphenol (BP-01A), anthracene (BP-02A and BP-02C), di-n-butylphthalate (BP-02C) and bis(2-ethylhexyl)phthalate (BP-02A and BP-02ADP).

Sample analysis for pesticides revealed 4,4'-DDT and its degradation products 4,4'-DDE and 4,4'- DDD. These compounds were only encountered in BP-02. BP-02C contained all of these compounds with concentrations up to 0.11 mg/kg (4,4'-DDD). The soils from this sample interval had a black staining. BP-02A, which had a maximum estimated concentration of 0.013 mg/kg of 4,4'-DDT, did not contain 4,4'-DDE. Background pesticide concentrations were non-detectable.

The alternate pesticide analysis revealed only one compound in concentration above that seen in the background sample. BP-01A contained 0.12 mg/kg of hexachlorobenzene. Two other compounds were detected but at concentrations within or less than the range of background concentrations. These compounds, seen only in BP-02A, are chlordene and 1,2,3,4,5,7,7-heptachlomorborene.

The inorganic analysis of the soil samples revealed concentrations above background for the following metals: cadmium, mercury, selenium, silver, sodium and thallium. The ranges of other metals overlapped and occasionally exceed those of the background samples. The implications and significance of the metals detected will be addressed in the risk assessment following a complete statistical analysis.

5.2.4 MONITORING WELL SOILS (GW) AND HAND AUGER BORINGS (HA)

Of the 13 new monitor well borings constructed on the Skinner site, split spoon soil samples were retained for analysis from the following locations: GW-26, GW-27, GW-28, GW-29, GW-35 and GW-38. The sampled intervals are indicated in Table 5.1 and the well locations are shown in Figure 2.2. Drilling methods are described in Section 2.4. Sampling of GW-27 is described in Section 5.2.2.

Each split spoon soil sample was screened with an Hnu and/or OVA meter with the resulting readings recorded on the well/boring logs. If the soil screening registered two times above the ambient air, or if the soils were visibly stained or had an unusual odor, the sample was retained for chemical analysis. Samples were retained for chemical analysis from the top, middle and bottom of any zone(s) of contamination encountered. A maximum of 5 and a minimum of 1 soil sample collected in the unsaturated zone was selected for chemical analysis from each borehole. If no soil sample failed the "meter, odor, visual" test, then the sample collected directly above the water table was selected for chemical analysis. Soil sampling methods were discussed in detail in Section 2.4.1.

The soil samples from the monitoring well borings were analyzed for RAS organics, RAS inorganics and SAS constituents including additional pesticides and TOC. A total of 22 soil samples were taken from the monitor well borings.

Hand auger soil borings were constructed at three locations, as described in Section 2.2 and presented in Figure 2.3. Soil samples were collected from 6 to 12 inches and from 18 to 24 inches below the ground surface and retained for chemical analysis.

These borings were positioned to assist in determining the impact of surface runoff from the active landfill towards the Duck (north) Pond. Additionally, these borings were located to assess the impact on the soils of partially buried drums observed adjacent to the pond. The soil samples were analyzed for RAS organics, RAS inorganics and SAS constituents, including additional pesticides. A total of 6 soil samples were taken from the hand auger borings.

5.2.4.1 Field Screening of Monitoring Well Soil Samples

The only monitoring well boring that contained soils with detectable organic vapors was GW-38, which contained readings up to 100 ppm in the upper 20 feet of sediment, concentrated in the 3.5 foot to 5 foot sample. No evidence of staining was recorded on the well log.

5.2.4.2 Laboratory Analysis of the Monitor Well and Hand Auger Borings (GW and HA)

The results of the analysis of the soil samples obtained from the monitor well and hand auger borings are discussed in this section. A summary table of the laboratory results is presented as Table 5.5. The indicated background values represent the GW-35 soil sample set. The risk assessment document will present a statistical analysis of the Phase II analytical results, incorporating chemical data from the Phase I investigation. The locations of the monitor wells and hand auger borings are shown in Figures 5.6 and 5.7.

The detection of volatile organic compounds in GW and HA samples is limited to soils in the waste lagoon area with one exception. Samples from GW-29, located on the western side of the site downslope from the metal storage area, contained low levels of chlorobenzene and xylene in the 3.5 through 5 foot sample interval. GW-38, located downslope from the buried waste lagoon, contained two compounds, methylene chloride and tetrachloroethene, in all of the sampled depth intervals. Xylene was detected in the first three samples at GW-38 and in the upper two samples from GW-28, also located downslope from the buried waste lagoon. Toluene was detected in GW-28B and GW-28C and in higher concentrations in HA-01B, HA-01BDP and HA-3B. Chlorobenzene and 2-butanone were each detected only once in HA-02B and HA-03B, respectively. The highest total volatile organic concentrations were seen in GW-38B (10.72 mg/kg) and GW-38BRE (12.72 mg/kg).

Semi-volatile organic compound detections present a similar spacial distribution to that of the volatile compounds. The samples from GW-29A and GW-29B contained benzoic acid. GW-29B also contained bis(2-ethylhexyl)phthalate, as did HA-01BDP and all the samples from GW-38. The samples from GW-38 and HA-01BDP also contained di-n-butylphthalate. Background concentrations of bis(2-ethylhexyl)phthalate and di-n-butylphthalate fell into the lower range of the investigative sample detections. The remaining semi-volatile detections were concentrated in HA-03A, HA-03B, GW-26A and GW-26B with total concentrations of 0.72 mg/kg, 0.47 mg/kg, 1.98 mg/kg and 0.568 mg/kg, respectively. HA-01BDP contained the highest total concentration, 13.74 mg/kg, due to the 12 mg/kg of bis(2-ethylhexyl)phthalate.

Pesticide and PCB detections were limited to GW-26A and to all samples from HA-01 and HA-03. GW-26A, located in the bedrock valley between the eastern and western ground water divides, contained 0.65 mg/kg of endrin. The hand auger samples contained up to 1.4 mg/kg of Aroclor 1254. These compounds were non-detect in the background sample set.

The alternative pesticide scan revealed hexachlorobenzene in GW-26A and GW-26B. The background concentration of this compound was 0.0038 mg/kg, less than the maximum of 0.077 detected in GW-26B. Hexachlorobutadiene was detected in HA-2A and HA-03B, but at a lesser concentration than the background sample. Similarly, the detection of 1,2,3,4,5,7,7-heptachlornorborene in HA-1BDP and GW-38 fell below the concentration range detected at GW-35.

The greatest concentrations of dioxins were detected in GW-38A, the 1 to 2.5 foot sample at that location. Compounds detected were octa CDD (192 ng/kg) and hepta CDD (205 ng/kg). Hepta CDD was also detected in GW-29B at a concentration of 1 ng/kg. The detection of furans was limited to GW-38B in the 3.5 to 5 foot sample, where total TETRA CDF and 2,3,7,8-TCDF were both detected at a concentration of 8 ng/kg.

Significant inorganic compound detections were limited to the buried waste lagoon area. These detections included antimony, cadmium, copper, mercury, nickel, silver, sodium and thallium. The risk assessment will include a statistical analysis of these detections.

5.2.5 SUMMARY OF SOILS CONTAMINATION

The analytical results of the Phase II soil sampling indicate three principal areas of concern: the buried waste lagoon and adjacent property, the buried pit, and possibly the area represented by GW-29 located downslope to the west of the metal storage area.

Compound detection in the buried waste lagoon soil samples appears to correlate with elevated field readings measured on an OVA or similar device and with soil stainings, where visible. Chemicals of concern include volatile organic compounds, semi-volatile organic compounds, pesticides, PCB's, metals, dioxins and furans. The risk assessment will provide a statistical analysis of the hazards presented by these compounds.

Some compound migration is suggested from the organic compound detections seen in downslope soils at GW-26, GW-38, and GW-28. The pesticides revealed during the investigation are, however, largely immobile, bind tightly to the clayey soils and have a low solubility in water. The permeability of the site soils appears to affect compound distribution, as revealed by the field sample screening. Additional point sources may exist to the north of the buried waste lagoon and in the area around GW-38.

Analysis of the buried pit area soil samples reveals generally lower compound concentration levels and a lesser number of compounds than seen at the buried waste lagoon area. Soil samples contained volatile organic compounds, semi-volatile organic compounds, pesticides, and metals.

Soil samples from GW-29 contained low levels of volatile and semi-volatile organic compounds, furans, and several metals. The number of compounds present is low and may be sourced in the metal storage area or originate in an isolated or localized spill.

5.3 GROUND WATER QUALITY

Twelve of the thirteen new monitoring wells constructed at the Skinner Landfill as part of the Phase II RI were sampled. One of the newly installed wells, GW-25, was dry at the designated time of sampling. In addition, samples were taken from 13 existing Phase I wells installed by WESTON in 1986 and two additional wells installed by the FIT team in 1982. This sampling was undertaken to further delineate the horizontal and vertical extent of the ground water contamination in the unconsolidated sediments and the shallow bedrock and to estimate the extent and rate of off-site contaminant migration. Ten of the thirteen Phase II wells were screened in the fractured bedrock with the remaining three wells screened in the unconsolidated sediments. Ground water samples were designated WW. For example WW06 is the ground water sample from monitor well GW06. The areal distribution of the ground water contamination is indicated on Figures 5.9, 5.10, and 5.11.

No future ground water sampling events are currently budgeted or scheduled under the Phase II RI scope. The network of wells now in place was designed to achieve both investigative and future ground water monitoring objectives. Based upon evaluation of the ground water quality and hydraulic data generated during this phase, no significant data gaps are evident and furthermore, this distribution of wells is anticipated to adequately satisfy the requirements of a monitoring network to assess the progress of the remedial strategy implemented.

A complete discussion of the sampling techniques utilized and the sample types collected was included in Section 2.7.

After purging, ground water samples were retained for field description and measurement. Parameters measured or described included pH, specific conductivity, temperature, color and noticeable odor. The specific conductivity, temperature and pH measurements are averaged for each sampled location and are included as Table 5.6. This table is divided into bedrock and unconsolidated sediment water.

5.3.1 Ground Water Sample Blank Contamination

Blank samples taken during the sampling of the ground water at the Skinner site were as follows: 5 field blank (FB), 10 trip blank (TB) and 9 atmospheric blank (AB) samples. The field blanks consisted of distilled water poured through the sampling equipment and into the sample containers. The atmospheric blanks consisted of deionized water poured into containers in the field and the trip blanks consisted of deionized water placed in sample containers at the field trailer and accompanying the investigative sample jars to the field and through shipping to the designated laboratory.

Compounds detected in blank samples and their ranges of detection are listed in Table 5.7. The most common volatile organic contaminants detected were methylene chloride, chloroform, toluene and 1,1,1-trichloroethane. Methylene chloride, chloroform and 1,1,1-trichloroethane were detected in almost all the blank samples. The blank samples WW30-AB, WW30-FB and WW30-TB contained more contaminants than the investigative ground water sample, WW30. This situation occurred with some frequency, indicating possible contamination of the deionized water used for the blank samples.

5.3.2 UNCONSOLIDATED SEDIMENT GROUND WATER (WW)

Fourteen of the sampled wells were screened in the unconsolidated sediments ranging in texture from sandy gravel to clay. Several of these wells (GW-11, GW-12 and GW-15) were constructed by WESTON to straddle the bedrock contact.

5.3.2.1 Field Screening of Ground Water Samples

Field measurements of the ground water samples collected are presented in Table 5.6. The highest average specific conductivity, 2,293 umhos/cm measured in WW-20, and the highest average pH value, 9.51 measured in WW-06, were found downgradient from the buried lagoon. The lowest average pH, 6.73, was also found downgradient from the buried lagoon in WW-20. The average pH value for the unconsolidated sediments was 7.41 with an average specific conductivity value of 1,189 umhos/cm.

5.3.2.2 Laboratory Analysis (Unconsolidated Ground Water)

The analysis of the groundwater sampled from the unconsolidated wells is presented in Appendix B. A summary table of analytical results was prepared for clarity and brevity and is presented as Table 5.8. This table indicates the number of detections for each compound and the ranges of detection. These tabulations take into account the effect of blank contamination as follows: if a compound was detected in an investigative sample at greater than or equal to 10 times the amount found in an associated blank sample, the detection was considered valid. If the detected amount was less than 10 times the blank concentration, the detection was considered invalid. Duplicates and resampled locations are included in the summary tables.

Fourteen of the monitoring wells sampled during the Phase II field work were screened in the unconsolidated sediments. Included in this group were those wells which were set straddling the bedrock contact (GW-11, GW-12 and GW-15). The summary tables for ground water from unconsolidated sediments also included duplicate samples associated with GW-10, GW-12 and GW-33.

The following sections briefly describe the detections and concentrations of compounds associated with ground water from the unconsolidated sediment. Ground water from GW-23, located upgradient from the landfill, was interpreted to be representative of background water quality. GW-36, on the west side of Skinner Creek, was also interpreted to be representative of background.

Volatile Organic Compounds

Two ground water samples, WW-20 and WW-B5 taken from wells located adjacent to and down gradient from the former waste lagoon, contained the majority of the volatile organic compound contamination seen in ground water at the Skinner site. Both wells were included on the cross sections introduced in the soil boring discussion and both wells appear to intersect the migrating contaminants originating from the buried waste lagoon. These ground water samples contained elevated levels of the following compounds: vinyl chloride, 1,1-dichloroethane, 1,2-dichloroethene, 1,2-dichloroethane, 1,2-dichloropropane, trichloroethene, benzene, chlorobenzene and ethylbenzene. WW-20 also contained chloroethane while WW-B5 additionally contained chloroform, 1,1,2-trichlorothane, tetrachloroethane and 1,1,2,2-tetrachloroethane.

Several other ground water samples contained volatile organic compounds. WW-07, taken from the shallow well located in the cluster adjacent to the East Fork of Mill Creek and downgradient from the waste lagoon, contained 1,2-dichloroethene. WW-11, taken from the well located downgradient and east of the waste lagoon, contained 1,2-dichloroethene and 1,2-dichloroethane.

WW-15, taken from the monitoring well located to the northwest of the waste lagoon in an area where the ground water flow is poorly defined, contained both benzene and chlorobenzene at low concentrations. The areal distribution of volatile organic compounds in ground water is indicated in Figure 5.9.

Semi-Volatile Organic Compounds

The distribution of semi-volatile compounds in ground water from the unconsolidated sediments is similar to that of the volatile organic compounds. The impact of the waste lagoon is evident in only those wells immediately adjacent to or downgradient from the lagoon. The following compounds were detected in more than one ground water sample: bis(2-chloroethyl)ether in WW-10, WW-20 and WW-B5; benzoic acid in WW-19 and WW-20; and naphthalene in WW-B5 and WW-20. The remaining detections occurred in only one ground water sample each: 2-chlorophenol (WW-B5), 1,3-dichlorobenzene (WW-B5), 1,4-dichlorobenzene (WW-B5), benzyl alcohol (WW-19), 1,2-dichlorobenzene (WW-B5), bis(2-chloroisopropyl)ether (WW-20), diethylphthalate (WW-20), phenanthrene (GW-06) and bis(2-ethylhexyl)phthalate (WW-B8). The areal distribution of semi-volatile compounds in ground water is indicated in Figure 5.10.

Pesticides/Alternate Pesticides

One compound on the pesticide scan was detected in ground water taken from a well screened in the unconsolidated sediments: WW-06 contained Aldrin at a concentration of 0.5 ug/L. This sample was taken from a well located down gradient from the waste lagoon along Mill Creek, the middle well in its cluster. Three compounds on the alternate pesticide list were detected in the unconsolidated sediment ground water: hexachlorobenzene was detected in WW-15 and hexachlorobutadiene was detected in both WW-B5 and WW-20. 1,2,3,4,5,7,7-heptachlornorborene was detected in WW-B5 and WW-10DP (DP = duplicate); however, the detection in WW-10DP is suspect due to the non-detect result from the WW-10 sample. The distribution of these contaminants is consistent with both the semi-volatile and volatile pattern. Only those samples from wells located downgradient from the waste lagoon appear impacted. The areal distribution of pesticides/alternate pesticides in ground water is indicated in Figure 5.11.

Inorganics

The detections of inorganic compounds in unconsolidated ground water are summarized in Table 5.8. A statistical analysis of these detections versus background values is presented in the Risk Assessment.

5.3.3 BEDROCK GROUND WATER (WW)

The evaluation of the extent of shallow bedrock contamination was a major objective of the Phase II RI. Of the 13 bedrock wells sampled, 10 were installed by WWES during Phase II.

5.3.3.1 Field Screening of Ground Water Samples

Field measurements of the ground water samples are presented in Table 5.6. The highest average specific conductivity, 4,713 uhmos/cm, was measured in WW-35, taken from a well located on the west side of Skinner Creek. The lowest specific conductivity value, 553 uhmos/cm, was measured in WW-29, taken from a well located between the metal storage area and the Diving Pond. The pH values measured ranged from 6.67 in WW-18 to 8.33 at WW-28. Average specific conductivity for the bedrock wells was 1,487 uhmos/cm and the average pH was 7.44.

5.3.3.2 Laboratory Analysis (Bedrock Ground Water)

A summary table was completed for the bedrock ground water in a similar format as the unconsolidated ground water and is presented as Table 5.9. The sample taken from GW-36 was considered to represent background ground water quality in the bedrock.

Thirteen of the monitoring wells sampled during the Phase II field work were screened in the bedrock. The bedrock ground water summary tables also included duplicate samples associated with GW-31 and GW-32.

Volatile Organic Compounds

Four volatile organic compounds were detected in ground water samples from three bedrock wells: carbon disulfide in WW-27 taken from a well located adjacent to the buried waste lagoon; benzene in WW-17 and WW-18; chlorobenzene in WW-17 and WW-18; and ethylbenzene in WW-24. WW-17 and WW-18 were taken from GW-17 and GW-18, screened within bedrock high to the north of the buried waste lagoon. As discussed in Section 4.4.3.3, ground water in these wells was interpreted to be in hydraulic communication with the ground water in the surrounding unconsolidated sediments. Further evidence for this conclusion is the existence of benzene, chlorobenzene and ethylbenzene in both the unconsolidated and bedrock ground water in this area. GW-18 was dry during one phase of WESTON's sampling but ground water from both it and well GW-17 contained detectable levels of volatile organics, benzene and 1,1,1-dichloroethane for example, during Phase I sampling.

The detection of an estimated 5 ug/l of ethyl benzene in ground water taken from GW-24 is the only observed evidence of volatile organic migration beneath the East Fork of Mill

Creek. The areal distribution of volatile compounds in ground water is indicated in Figure 5.9.

Semi-Volatile Organic Compounds

The detection of semi-volatile organic compounds in the bedrock followed a pattern similar to the volatile organic compounds. Only three compounds were detected within four ground water samples: phenol in WW-18, WW-29 and WW-31DP; 1,4-dichlorobenzene within WW-17 and WW-18; and naphthalene in WW-17. Contamination of samples taken from GW-17 and GW-18 follows similarly from that of the volatile organic compounds. The detection of phenol in WW-31DP may be suspect due to the non-detect in the accompanying investigative sample. The potential source area of the 2 ug/l of phenol in WW-29 is unknown. The areal distribution of semi-volatile compounds in ground water is indicated in Figure 5.10.

Pesticides/Alternate Pesticides

The analysis of bedrock ground water did not reveal any compounds from the standard pesticide list. The alternate pesticide scan revealed contamination in two bedrock ground water samples: WW-18 contained hexachlorobenzene and WW-09 contained hexachlorocyclopentadiene, hexachlorobutadiene, chlordene and 1,2,3,4,5,7,7-heptachloronorborene.

These compounds are for the most part dense chlorinated breakdown products of the pesticides detected in the buried lagoon soils. Pesticide contamination of GW-18 follows the previously defined route of entry. GW-09 is located immediately downgradient from the waste lagoon in the bedrock which forms the buried valley floor. The well is appropriately situated to intercept contaminant movement as the screened interval is only a few feet below the bedrock surface. Ground water from GW-20, screened upgradient from this location within the glacial deposits, contained hexachlorobutadiene. WW-10, taken from GW-10, the well in this cluster screened in the unconsolidated sediments, contained 1,2,3,4,5,7,7-heptachloronorborene. The areal distribution of pesticide/alternate pesticide compounds in ground water is indicated in Figure 5.11.

Inorganics

The detected inorganic compounds in bedrock ground water are summarized in Table 5.9. A statistical analysis of these detections versus background values is presented in the risk assessment.

5.3.4 Residential Wells Ground Water (RW)

Four residential wells, two off site and two on site, were sampled during the Phase II investigation. Section 2.10 discusses the location of and the rationale for sampling these wells. Figures 2.2 and 2.4 indicate the residential well locations. In general, the on-site wells were sampled to determine the immediate risk to the Skinner site residents. The off-site wells were selected based upon their elevation of completion relative to the elevation of known contamination at the Skinner site.

5.3.4.1 Laboratory Analysis (RW)

Summary tables were not prepared for the residential wells as only three compounds were detected in two wells. RW-01, the well supplying Elsa and Ray Skinner's residences, contained naphthalene at a concentration of 0.73 ug/l while RW-25, located at 8754 Lousordville in West Chester, contained 0.31 ug/l of diethyl phthalate and RW-25RE contained 1 ug/L of bis(2-ethylhexyl)phthalate. In summary, essentially no impact to area residential wells was observed in the samples collected.

5.3.5 Summary of Ground Water Contamination

Ground water contamination in the unconsolidated sediments appears to originate within the buried waste lagoon and nearby areas. Wells located immediately adjacent and downgradient from the lagoon are the most severely impacted. Contamination may be migrating preferentially through the more permeable sediments on the southeastern side of the lagoon, based upon the contaminant distribution. The pesticides detected are, for the most part, insoluble and immobile, adsorbing strongly onto the surrounding soils. The base of the waste lagoon is located above the water table and direct interaction between the lagoon wastes and ground water is minimal.

Contamination of GW-15, GW-17 and GW-18, located to the north of the main lagoon area, may reflect alternate pollutant sources. This is difficult to define however, due to the poorly defined ground water flow in that area. Historically, the area to the north of the lagoon and active fill areas contained drums which, when sampled in 1976, contained benzene, ethyl benzene and toluene. WESTON's surface geophysical surveys appeared to define several possible buried drum nests in the area to the northwest of the buried lagoon indicating that there may be several point sources of contaminants.

One of the monitoring wells screened in the unconsolidated sediments (GW-06) contained free floating oil on the water table. The source of this oil is unknown and its thickness was not measured. No significant dissolved constituents were detected in ground water samples from this well, indicating the oil may be old and is not releasing volatile organic compounds to the ground water. GW-06 is screened in a stiff clayey unit which would impede migration of contaminants. This unit was penetrated by the GW-38 boring and revealed no visible signs of contamination when examined via the split spoon samples. Given the unlikely occurrence of the oil's migration into the well through the screened unit, the oil may have migrated from the surface down the borehole or, perhaps, have been placed into the well. No mention of oil in the well or in the sediments was made by WESTON during the drilling and sampling of GW-06. It is believed that this oil is a localized occurrence.

Bedrock ground water contamination appears limited to the area northwest of the waste lagoon near GW-17 and GW-18. These wells appear to be screened within a bedrock high which protrudes into and above the unconsolidated sediment water table. Both bedrock and unconsolidated ground water in this area contain benzene, chlorobenzene and ethylbenzene. Contaminants which originate in the buried lagoon or elsewhere may enter the bedding planes or fractures and flow through this portion of bedrock. As stated previously, the drummed solvents discovered in 1976 may be the origin of these contaminants.

The ground water contamination present in the bedrock well GW-09 appears to originate in the waste lagoon. The contaminants are principally dense chlorinated compounds which were known to be disposed of in the waste lagoon but are also associated with the breakdown of the waste lagoon pesticides. The location of the well screen, just beneath the bedrock contact on the floor of the buried valley, may have created a conduit for contaminated ground water, that had migrated from the waste lagoon through unconsolidated sediment to reach the bedrock at GW-09.

5.3.6 Historic Trends in Ground Water Contamination

This section briefly describes trends in contamination as revealed by historical and recent analytical results. Appendix B contains the complete historical chemical analysis record.

5.3.6.1 Abandoned Pre-Phase II Wells

As stated in Section 2.9, GW-8 and GW-13 were screened in the unconsolidated sediment vadose zone and were abandoned as part of the Phase II field investigation. The small number of ground water samples taken from these wells did not reveal significant variety or levels of contamination.

GW-16, previously located in the unconsolidated sediments adjacent to the present location of GW-26, was abandoned due to its position in or near the roadway. Ground water analysis from this well did not reveal elevated levels of the analyzed constituents.

GW-21 and GW-22 were formerly located on the eastern side of the buried waste lagoon and screened in the unconsolidated sediments. GW-21 was positioned on top of the steep slope to the west of GW-11 while GW-22 was located to the north of the buried waste lagoon across the access road. GW-21 was positioned to intercept contaminants migrating to the east of the lagoon while GW-22 was positioned to define contamination to the north of the lagoon where drums of solvents are suspected to be buried. Both of these wells were inaccessible and were abandoned due to the landfilling activities which continued at the Skinner Landfill until the fall of 1990.

Historically, the compounds detected in GW-21 were few in number and low in concentration. Similar detection lists and concentrations were seen in GW-11 and GW-12, supporting the flow patterns defined in Section 5 of this report.

The last sample from GW-22, taken in 1987, revealed a trend of increasing volatile organic compound concentrations. This increase could have been a result of altered infiltration/hydrogeological conditions resulting from the placement of the solid waste material over the adjacent buried lagoon. This placement occurred between the August 1986 and July 1987 sampling events. The increase could be an indication of the migration of a more highly concentrated zone within the ground water plume, in the direction of GW-22 or toward Mill Creek.

Based upon the results of the Phase II investigation, the source of the contamination found in GW-22 is probably not the buried waste lagoon. The greatest compound concentrations encountered in GW-22 during the 1987 sampling event were benzene (20,000 ug/l), chlorobenzene (140 ug/l), ethylbenzene (100 ug/l), hexachlorocyclopentadiene (100 ug/l), methylene chloride (2200 ug/l), toluene (539 ug/l), and xylene (300 ug/l). Downgradient wells GW-11 and GW-12 did not contain the variety or concentrations of compounds detected in GW-22.

5.3.6.2 Existing Pre-Phase II Wells

The detection lists from the Phase I and Phase II sampling events were compared to produce the following observations. The compound analysis lists were not consistent between the sampling events causing the comparisons to eliminate some detections.

- GW-06 Confirmed acetone detection and concentration.
- GW-07 No compounds confirmed.
- GW-09 Confirmed hexachlorocyclobutadiene detection and concentration.
- GW-10 Confirmed bis (2-chloroethyl) ether detection and concentration.
- GW-11 No compounds confirmed.
- GW-12 Confirmed toluene detection and concentration.
- GW-14 Confirmed carbon tetrachloride detection and concentration.
- GW-17 Confirmed 1,4-dichlorobenzene, benzene and napthalene detections and concentrations.
- GW-18 Confirmed 1,4-dichlorobenzene, benzene detection and concentrations.
- GW-19 Benzoic acid concentration very high in Phase II but compound not detected in Phase I. Confirmed toluene and 2-butanone detections and concentrations.
- GW-20 Confirmed 1,2-dichloroethane, benzene, bis(2-chloroethyl)ether, chlorobenzene, chloroethane, ethylbenzene and napthalene

detections and concentrations. Toluene, xylene and benzoic acid were confirmed detected but in significantly lower concentrations in Phase II samples. Methylene chloride and acetone were detected consistently in previous rounds but not detected in Phase II sampling.

- GW-23 No compounds confirmed.

5.4 LEACHATE, SURFACE WATER AND SEDIMENT QUALITY

Sediments and surface water from three creeks, three ponds and three leachate seeps were sampled during the Phase II field work. Figure 5.8 is a map of the site which indicates these features and the sampling locations. The sample locations were selected to obtain adequate data for the establishment of background values, to facilitate a comparison of Phase II laboratory data with Phase I data, and to assess the extent of any contamination downstream from the Skinner Landfill site. In addition, WWES selected the sample locations to optimize surface water and sediment quality characterization for risk assessment.

The leachate samples were analyzed for RAS organics, RAS inorganics and additional SAS parameters.

Section 2.1 describes the sampling methodology in detail. Surface water sources and the number of samples collected are as follows:

Creeks (SF and SM)

The creeks sampled during the Phase II investigation included the East Fork of Mill Creek (referred to as Mill Creek), Skinner Creek, and a very small creek on the east side of the active landfill (referred to as Dump Creek for convenience). Dump Creek divides into east, middle and west branches. The total number of creek samples was 28 water and 26 sediment samples. The creeks were sampled from downstream to upstream locations.

Ponds (SF and SM)

The ponds sampled included a pond to the north of the active landfill and north of the Skinner Landfill property, and two ponds along Skinner Creek on the west side of the site. The pond north of the landfill is referred to as "Duck Pond", the northern pond along Skinner Creek is referred to as "Diving Pond," and the southern pond along

Skinner Creek is referred to as "Trilobite Pond." These names were assigned for convenience in referring to the sampling areas. The total number of pond samples was 12 water and 6 sediment samples.

Leachate Seeps (LW and LS)

Two leachate seepage areas along Mill Creek and one area along Skinner Creek were sampled. The seepage areas along Mill Creek had been identified in the Phase I study and were included in the Sampling Plan for the Phase II study. The seepage area sampled along Skinner Creek was identified during implementation of the Phase II study. The total number of leachate samples was three water and three sediment samples.

5.4.1 LEACHATE, SURFACE WATER AND SEDIMENT BLANK CONTAMINATION

The blanks associated with the surface water, sediment and leachate sampling were as follows: 24 atmospheric blanks (AB), 8 field blanks (FB) and 24 trip blanks (TB). Methods of preparation follow those described in the previous sections. The sediment blanks consisted of silica sand with the remaining blanks consisting of deionized water.

A summary of the compounds detected in the blanks is presented in Table 5.10. The common contaminants addressed in the previous discussions of blanks were also seen in this series. Common volatile organic compounds occurring in the blank samples included chloroform, methylene chloride and acetone. Because degradation of air quality would not be expected during this type of sampling, the discovery of these compounds in the atmospheric blank samples may be related to a contaminated deionized water source or to laboratory introduced contamination. As seen in the ground water sampling, blank contamination occurred even when the associated investigative sample was not contaminated.

The detections of semi-volatile compounds in field blanks were few in number and at low concentrations. These detections are possibly false analytical positives or may represent low level residual contamination of sampling equipment.

5.4.2 FIELD SCREENING OF LEACHATE, SURFACE WATER AND SEDIMENT SAMPLES

Field measurements of surface water samples were made as specified in the Sampling Plan. Temperature, pH, and specific conductivity were measured in the water samples and Hnu readings were made of the sediment samples. Table 5.11 presents the averages of the various field measurements arranged by source areas. The following is a general discussion of these measurements:

Creeks (SF and SM)

Average specific conductivities in the creek samples ranged from 729 uhmos/cm in Mill Creek to 931 uhmos/cm in Skinner Creek. The highest single measurement, 1092 uhmos/cm, was seen in SF-16, located on Dump Creek adjacent to the active landfill. The average measurement for Dump Creek was 806 uhmos/cm. The pH measurements in Skinner Creek and Mill Creek were nearly identical, 8.29 and 8.32, respectively. The average pH in Dump Creek was 7.52. Organic vapor screening of the sediment samples from the creek did not reveal detectable levels.

Ponds (SF and SM)

The field parameters associated with the pond water samples varied. Duck Pond contained water with an average pH of 7.3 and an average specific conductivity of 185 uhmos/cm. Trilobite Pond water had an average specific conductivity of 615 uhmos/cm and an average pH of 8.02. Neither of these ponds contained detectable sediment vapors. Diving Pond sediments produced a maximum reading of 11.4 ppm on the organic vapor detector (Hnu). Average specific conductivity was 240 uhmos/cm and average pH was 9.22.

Leachate Seeps (LW and LS)

Only one leachate sample was associated with Skinner Creek. This water sample had a pH of 7.07 and a specific conductivity of 741 uhmos/cm. The other two leachate seeps were located down gradient from the landfill and appeared to discharge into Mill Creek. The average specific conductivity of these samples was 2,231 uhmos/cm and the average pH was 7.26. No measurable vapors were associated with any sediment samples.

5.4.3 Laboratory Analyses of Surface Water and Sediment Samples

The results of laboratory analyses of surface water and sediment samples are discussed in the following sections. Sampling locations are shown in Figure 5.8. Summary tables of the laboratory results were prepared following the same protocol as with the soil and ground water summaries. The most prevalent chemical constituents detected are discussed in the text. A more detailed evaluation of the laboratory results of surface water and sediment samples is presented in the risk assessment.

5.4.3.1 East Fork of Mill Creek Water Samples

A summary of analytical results on East Fork of Mill Creek water samples is presented in Table 5.12. Only one volatile organic compound was detected in the creek water. Xylene was detected at 3 ug/l from sample station SF07 located downstream of the landfill just off the Skinner Landfill property.

Two semi-volatile organic compounds, diethylphthalate and di-n-butylphthalate, were detected in creek samples. Di-n-butylphthalate was detected in 6 of the 13 samples with concentrations ranging from 1 to 10 ug/l. These concentrations are within the range of detections in background (upstream) sample locations (SF12, SF13, SF14, and SF15) and, therefore, are not interpreted to be attributable to landfilling operations at the Skinner site.

One pesticide, hexachlorobenzene, was detected in the background creek sample SF13 located upstream of the railroad bridge east of the Skinner site. This occurrence is not interpreted as attributable to landfilling operations at the Skinner site.

A summary of inorganic compounds detected in East Fork of Mill Creek samples is presented in Table 5.12. A statistical comparison of these detections to background concentrations is presented in the risk assessment.

5.4.3.2 East Fork of Mill Creek Sediment Samples

A summary of laboratory analyses of East Fork of Mill Creek sediment samples is presented in Table 5.13. No volatile organic compounds were detected at concentrations in exceedance of the range of concentrations detected in background (upstream) sediment samples (SF12, SF13, SF14, SF15). Acetone was detected at 2 locations adjacent to or downstream of the landfill, but below the concentrations detected in background samples.

A variety of semi-volatile organic compounds were detected in creek sediment samples. Table 5.13 provides a summary of the frequency of these detections and the range of concentrations measured. The highest concentration of a single semi-volatile compound detected was 3.3 mg/kg of fluoranthene from SM02 located downstream of the Skinner property. The highest total semi-volatile concentrations detected (sum of all semi-volatile concentrations from one sampling location) were 15.32 mg/kg and 19.74 mg/kg from SM01 and SM02 respectively. These sample stations are located downstream of the Skinner site. Some debris (cement blocks, boulders, trash) was noted near sample location SM01, but no definitive source of these compounds is known. The widespread distribution of the semi-volatile compounds in the creek sediments suggests that a source exists upstream and the contaminated sediment was transported and deposited along the course of the creek bed within the Skinner site. It should be noted that burned wood and trash piles are located along the north side of Mill Creek and may be the source of semi-volatile compounds in the creek via site runoff.

Pesticide and PCB compounds detected in creek sediments sampled include beta-BHC (SM03), 4,4'-DDD (SM02), alpha-chlordane (SM07), and Aroclor-1254 (SM07). The sample locations where these compounds were detected are located downstream of the waste lagoon area.

Pesticides from the alternate pesticide scan were also detected in creek samples. The only compound which was detected above background concentrations was hexachlorobenzene which was detected in 9 of the 12 observations.

A summary of inorganic compounds detected in East Fork of Mill Creek sediments is shown in Table 5.13. Statistical comparisons of the detected concentrations to background are presented in the Risk Assessment. Mercury, selenium, and silver were detected in creek sediments adjacent to or downstream of the landfill, but not detected from upstream (background) samples suggesting that a source for these metals exists on the Skinner site.

5.4.3.3 Skinner Creek Water Samples

A summary of analytical results of Skinner Creek water samples is presented in Table 5.14. No volatile organic compounds were detected in any of the Skinner Creek samples.

Three semi-volatile organic compounds were detected in the creek samples: phenol (SF23), diethylphthalate (SF22, SF24), and butylbenzylphthalate (SF37). None of these semi-volatile compounds was detected at concentrations greater than 3 ug/l.

One pesticide compound, 1,2,3,4,5,7,7-heptachloronorborene, was detected at 0.15 ug/l in the background (upstream) sample location SF26.

A summary of inorganic compounds detected in Skinner Creek water samples is shown in Table 5.14. No obvious exceedances of background concentrations were noted for inorganic compounds and a statistical comparison of the investigative results to background levels is presented in the Risk Assessment.

5.4.3.4 Skinner Creek Sediment Samples

A summary of laboratory results of Skinner Creek sediment samples is shown in Table 5.15. Three volatile organic compounds were detected from Skinner Creek sediments: acetone (SM20 and SM21), 1,2-dichloroethene (SM21-DP), and trichloroethene (SM21-DP). SM21 is located near the buried pit area and SM20 is located downstream on the western side of the main access road.

A variety of semi-volatile organic compounds were detected in Skinner Creek sediment samples. Table 5.15 provides a summary of the frequency of these detections and the range of concentrations detected. The highest concentration of a single semi-volatile organic compound detected was 2.5 mg/kg of fluoranthene from SM21. The highest total semi-volatile concentration from Skinner Creek sediment samples was also from SM21 (9.77 mg/kg). A variety of semi-volatile organic compounds were also detected from the background (upstream) sediment sampling station SM26. A statistical evaluation of semi-volatile organic compounds in Skinner Creek sediments is presented in the risk assessment.

Five of the compounds from the alternate pesticide SAS scan were detected in Skinner Creek sediment samples. A summary of these detections is shown in Table 5.15. The pesticide compounds detected were: hexachlorobenzene, hexachlorocyclopentadiene, hexachlorobutadiene, 1,2,3,4,5,7,7-heptachloronorborene, and chlordene. These compounds were detected at multiple sampling locations. The highest total concentration of these pesticide compounds were detected at SM20 and SM21 (0.0809 and 0.0888 mg/kg respectively).

A summary of inorganic compounds detected in Skinner Creek sediment samples is shown in Table 5.15. Statistical comparisons of the detected concentrations to background are presented in the risk assessment. Two metals, cadmium and copper, were detected in investigative samples but not detected in background samples suggesting a possible source of these metals exists on the Skinner site.

5.4.3.5 Dump Creek and Duck Pond Water Samples

A summary of laboratory analyses of Dump Creek and Duck Pond water samples is shown in Table 5.16. These two units were combined because they are both fed, in part, through run-off from the active fill area. The location of these units is shown in Figure 5.8.

No volatile organic compounds were detected in Dump Creek or Duck Pond water samples. Three semi-volatile organic compounds were detected. Two of these compounds, bis(2-chloroisopropyl)ether and pyrene were detected at 3 ug/l and 1 ug/l respectively from Dump Creek samples. Di-n- butylphthalate was detected at 2 ug/l from a Duck Pond sample.

A summary of inorganic compounds detected in Dump Creek and Duck Pond water samples is shown in Table 5.16. A statistical comparison of these results to background levels is presented in the Risk Assessment. Background water quality for these two units is from the upstream Dump Creek sampling station SF18.

5.4.3.6 Dump Creek and Duck Pond Sediment Samples

A summary of laboratory analyses of Dump Creek and Duck Pond sediment samples is presented in Table 5.17. Background sediment quality for these units is from the upstream Dump Creek sampling station SM18.

Two volatile organic compounds were detected in sediments from these units. Toluene was detected from the background sediment sample SM18 and acetone was detected from the Dump Creek sample location SM19.

A variety of semi-volatile organic compounds were detected. A summary of these detections is shown in Table 5.17. All of the semi-volatile organic compounds detected were from sampling stations SM16 and SM17 in Dump Creek with the exception of one detection of di-n-butylphthalate from SM19 in Dump Creek and a detection of bis(2-ethylhexyl)phthalate from SM27 in Duck Pond.

The four pesticide compounds listed in Table 5.17 were all detected from Duck Pond sediment samples with the exception of hexachlorobutadiene which was detected from Dump Creek sampling station SM19.

A summary of inorganic compounds detected in Dump Creek and Duck Pond sediments is shown in Table 5.17. A statistical comparison of these results to background (SM18) concentrations is presented in the Risk Assessment. The only inorganic compound detected in investigative samples but not detected in background samples is thallium, which was detected in 5 of the 6 investigative samples.

5.4.3.7 Diving and Trilobite Ponds Water Samples

A summary of laboratory analyses of Diving and Trilobite Pond water samples is shown in Table 5.18. These ponds were combined because of their close proximity to one another and similar physiographic location above Skinner Creek. Background water quality for the Diving and Trilobite Ponds is from the 3 water samples collected from Duck Pond (SF-27, SF-28, and SF-29).

No volatile organic compounds were detected in water samples from the Diving or Trilobite Pond. Three semi-volatile organic compounds were detected from Trilobite Pond: phenol (SF35B), dimethylphthalate (SF33B), and diethylphthalate (SF33B and SF35B). The "B" samples noted on the laboratory report sheets were collected from near the bottom of the pond.

Two pesticide compounds were detected in the ponds. Hexachlorobenzene was detected in sample SF31-DP from Diving Pond and hexachlorobutadiene was detected in samples from both ponds.

A summary of inorganic compounds detected in Diving and Trilobite Pond water samples is shown in Table 5.18. A statistical comparison of these detections to background values is presented in the Risk Assessment. Five metals were detected in these ponds, but not detected in background samples. These metals were: antimony, barium, cadmium, nickel, and vanadium. Antimony and nickel were found only in the Diving Pond and may be related to surface runoff, or ground water discharge, from the metal storage area located topographically upgradient from the pond.

5.4.3.8 Diving and Trilobite Ponds Sediment Samples

A summary of analytical results on Diving and Trilobite Pond sediment samples is presented in Table 5.19. Two volatile organic compounds, 2-butanone and xylene, were detected in Diving Pond sediments. No volatile organics were detected in sediments from Trilobite Pond.

A variety of semi-volatile organic compounds were detected in the Diving Pond. Of the list of semi-volatile organic compounds shown in Table 5.19, only one detection, of bis(2-ethylhexyl)phthalate, was from Trilobite Pond sediments.

Two PCB compounds, Aroclor-1254 and Aroclor-1260, were detected in sediment samples from Diving Pond. No PCB compounds were detected in Trilobite Pond sediments. The maximum concentration of a PCB compound detected in Diving Pond sediments, 0.43 mg/kg of Aroclor-1260, confirms the 0.442 mg/kg detected in the pond sediment during Phase I sampling.

Three pesticide compounds were detected in Diving Pond sediments at concentrations up to 0.0037 mg/kg. Only one detection of a pesticide compound was made in sediment samples from Trilobite Pond, 0.0017 mg/kg of 1,2,3,4,5,7,7-heptachloronorborene.

Diving Pond sediments contained significantly more organic compounds than Trilobite Pond sediment. Observations made while sampling sediments from Diving Pond of "oily sheens" and "petroleum smell" also indicate that the sediments of this pond have been impacted. The sediments of Trilobite Pond were not as significantly impacted; however this pond has been altered by dredging and excavating activities by the landfill operators such that historical impacts to the pond sediments are not determinable.

A summary of inorganic compounds detected in sediments from Diving and Trilobite Ponds is presented in Table 5.19. A statistical analysis of these detections is presented in the Risk Assessment. The ranges of concentrations of inorganic compounds detected in Diving and Trilobite Pond sediments are generally similar to the background sediment values.

Background values presented in Table 5.19 represent the sediment samples taken from Duck Pond. These sediments were impacted and may not represent actual background conditions on the Skinner Site. The Risk Assessment will evaluate the validity of this background location and, if necessary, provide other background locations for the evaluation of Trilobite and Diving Ponds sediment contamination. The possibility exists that background at the Skinner site is contaminated.

5.4.3.9 Leachate Water Samples

A summary of analytical results on leachate water samples is shown in Table 5.20. LW01 and LW02 are located along the East Fork of Mill Creek, down gradient of the buried waste lagoon, and LW03 is located along Skinner Creek, near the Trilobite Pond. These sample locations are shown in Figure 5.8.

Three volatile organic compounds (benzene, chloroethane, and 1,1-dichloroethane) were detected in leachate water samples from LW-01 along the East Fork of Mill Creek. No volatile organic compounds were detected from LW-03, the leachate seep along Skinner Creek. One semi-volatile compound, bis(2-chloroethyl)ether, was detected from LW-01 at concentrations from 100-120 ug/l.

One pesticide compound, hexachlorobutadiene, was detected from leachate seeps from both creeks. This compound was also detected in a water sample from Trilobite Pond, indicating that the leachate seep (LW-01) and the pond may be in hydraulic communication.

A summary of inorganic compounds detected in the leachate water is shown in Table 5.20. The Risk Assessment evaluates which, if any, of these compounds pose a threat to human health or the environment.

5.4.3.10 Leachate Sediment Samples

A summary of laboratory analyses of leachate sediment samples is presented in Table 5.21. Three volatile organic compounds were detected from leachate sediments: methylene chloride and 2-butanone were detected in leachate sediments near both creeks and toluene was detected only in LS-01 near the East Fork of Mill Creek.

A variety of semi-volatile compounds and four pesticides were detected in leachate sediments near the East Fork of Mill Creek, but no semi-volatiles and only one pesticide compound were detected in leachate sediments near Skinner Creek.

A summary of inorganic compounds detected in leachate sediments is presented in Table 5.21. The Risk Assessment evaluates which of these compounds, if any, are significantly threatening to human health or the environment.

5.4.4 Summary of Surface Water and Sediment Sampling

The results of the laboratory analyses on surface water and sediment samples from the Skinner site showed the presence of volatile organic compounds, semi-volatile organic compounds, pesticides, PCB's and metals at low concentrations.

No significant surface water contamination of East Fork of Mill Creek was observed. A variety of semi-volatile organic compounds, pesticides, and PCB's were detected in sediment samples from the creek, however.

Similar observations were made of Skinner Creek as no significant surface water contamination was observed, but volatile organic, semi-volatile, and pesticide compounds were detected in Skinner Creek sediment samples. The area of Skinner Creek where the sediments were most heavily impacted was in the vicinity of SM20 and SM21 near the buried pit and the main access road to the site.

Water samples from Duck Pond and Dump Creek did not reveal significant amounts of contamination. The sediments of the Duck Pond were shown to be impacted by pesticides while Dump Creek sediments contained detectable levels of volatile organics, semi-volatiles, and a single low level detection of a pesticide compound.

Water samples from Trilobite and Diving ponds both contained low concentrations of pesticides and semi-volatile organics were detected in water collected near the base of the trilobite pond. Sediments from Diving Pond contained detectable levels of volatile organics, semi-volatile organics, PCB's and pesticides. The sediment samples from Trilobite Pond were relatively unimpacted, but have been recently disturbed and altered through dredging and excavating activities by the landfill operator.

The leachate seeps entering the East Fork of Mill Creek contained volatile organics, semi-volatile organics, and pesticide compounds in the leachate water and sediment. The only significant organic compound detected in the leachate water from the Skinner Creek seep (LW-03) was the pesticide hexachlorobutadiene. This pesticide compound was also detected in a water sample from Trilobite Pond suggesting that the pond and the seep are in hydraulic communication. This suggestion is supported by pH and specific conductivity values. Petroleum odors, however, seem to link this seep to the Diving Pond.

The set of compounds detected in LW-01 were also found in the ground water sample obtained from GW-20, located upgradient of the leachate seep and below the waste lagoon. This pattern suggests that the seep is a direct discharge point for ground water originating in and impacted by the waste lagoon. Discharge at LW-01 may be induced or aided by the drainage pipe while discharge at LW-02 appears to be controlled by lithology, as discussed in Section 4.4.4 and supported by the soil vapor screening discussed in Section 5.2.2.1. Average specific conductivity measurements of both LW-01 and LW-02 closely match that of the ground water sample obtained from GW-20 while pH values in the leachate samples were only slightly higher. The leachate sample LW-01 did not contain any of the contaminants detected in LW-02 but the corresponding sediment sample, LS-01, contained many of the same compounds as LS-02. The majority of detections in the sediments were semi-volatile compounds.

The risk assessment submitted in December 1990 compared the results of the on-site surface water and sediment sampling on the Skinner site to background sample locations. This process of comparison will determine if the contamination encountered is attributable to the historic disposal process or attributable to off-site sources and evaluates which, if any, of the compounds pose a threat to human health or the environment.

5.5 MAGNITUDE AND SOURCES OF CONTAMINATION

The buried waste lagoon contains the bulk of the soil contamination present on the Skinner site and acts as the source of the majority of the ground water contamination east of the ground water divide. Wells located immediately adjacent to and downgradient from the lagoon are the most severely impacted. Chemicals of concern in the buried waste lagoon include volatile organic compounds, semi-volatile organic compounds, pesticides, metals and very low levels of PCB's, dioxins and furans. The pesticides detected are, for the most part, insoluble and immobile, adsorbing strongly onto the surrounding soils. The base of the waste lagoon is located above the water table and direct interaction between the lagoon wastes and the unconsolidated sediment water table is minimal.

Infiltrating water, however, interacts with the waste and both saturated and unsaturated flow follows the more permeable sediments. Migration of volatile compounds is evidenced by the field screening and by the contamination encountered in the ground water samples from GW-20 and B-5. Elevated bedrock contaminant concentrations are limited to GW-17 and GW-18, located to the north of the buried lagoon within a bedrock high. The bedrock ground water in this area interacts with the unconsolidated sediments ground water. Contamination in these wells may be due to the historical storage of drummed solvents to the north of the buried lagoon.

Leachate seeps discharging into the East Fork of Mill Creek may originate within or below the buried waste lagoon as evidenced by the similarity in the compounds encountered, pH and specific conductivity measurements.

The results of the laboratory analyses performed on surface water and sediment samples from the Skinner site showed the presence of volatile organic compounds, semi-volatile organic compounds, pesticides, PCB's and metals at low concentrations. The risk assessment will compare these detections to background samples to determine if the contamination encountered is attributable to the historic disposal practices.

Additional point sources of soil and ground water contamination may occur to the north of the buried waste lagoon. Sources within or near the metal storage area, west of the ground water divide, may account for contaminants detected in the diving pond. These contaminants in the diving pond are more likely sourced from surface runoff. The PCB's encountered in the Diving Pond sediments represent another contaminant source.

SECTION 5

TABLES

Table 5.1

Skinner Landfill

Phase II Sampling

Soil Sample Intervals

Location	A	B	C	D	E	F	G	H
	Sample Interval Depth (feet)							
BL-01	3.5 - 5.0	8.5 - 10.0	20.5 - 22.0	23.5 - 24.5	30.5 - 32.0	33.5 - 35.0	38.5 - 40.0	43.5 - 45.0
BL-02	4.0 - 5.5	8.5 - 10.0	13.5 - 15.0	18.5 - 21.5	23.5 - 25.0	27.5 - 29.0	29.0 - 30.5	-
BL-03	7.5 - 9.0	-	-	-	-	-	-	-
BP-01	1.0 - 2.5	-	-	-	-	-	-	-
BP-02	0.0 - 1.5	3.5 - 5.0	6.0 - 7.5	8.5 - 10.0	-	-	-	-
BP-03	0.0 - 2.0	-	-	-	-	-	-	-
GW-26	1.0 - 2.5	13.5 - 15.0	-	-	-	-	-	-
GW-27	1.0 - 2.5	23.5 - 25.0	28.5 - 30.0	33.5 - 35.0	38.5 - 40.0	43.5 - 45.0	-	-
GW-28	3.5 - 5.0	6.0 - 7.5	9.0 - 10.5	-	-	-	-	-
GW-29	1.0 - 2.5	3.5 - 5.0	-	-	-	-	-	-
GW-36	1.0 - 2.5	3.5 - 5.0	6.0 - 7.5	13.5 - 15.0	28.5 - 29.3	-	-	-
GW-38	1.0 - 2.5	3.5 - 5.0	6.0 - 7.5	13.5 - 15.0	-	-	-	-
HA-01	0.5 - 1.0	1.5 - 2.0	-	-	-	-	-	-
HA-02	0.5 - 1.0	1.5 - 2.0	-	-	-	-	-	-
HA-03	0.5 - 1.0	1.5 - 2.0	-	-	-	-	-	-
WL-01	19.5 - 21.5	21.5 - 25.5	-	-	-	-	-	-
WL-02	15.5 - 17.5	21.5 - 23.5	-	-	-	-	-	-
WL-03	17.0 - 19.0	19.0 - 21.0	21.0 - 23.0	27.0 - 29.0	29.0 - 31.0	-	-	-
WL-04	13.5 - 15.5	17.5 - 19.5	21.5 - 23.5	-	-	-	-	-
WL-05	23.0 - 25.0	27.0 - 29.0	43.0 - 45.0	-	-	-	-	-
WL-06	-	24.0 - 28.0	27.5 - 32.0	-	-	-	-	-
WL-07	19.0 - 21.0	21.0 - 23.0	25.0 - 27.0	27.0 - 29.0	31.0 - 33.0	-	-	-
WL-08	17.0 - 19.0	23.0 - 25.0	-	-	-	-	-	-
WL-09	25.0 - 27.0	31.0 - 33.0	-	-	-	-	-	-
WL-10	22.0 - 26.0	30.0 - 32.0	-	-	-	-	-	-
WL-11	22.0 - 24.0	26.0 - 28.0	30.0 - 32.0	-	-	-	-	-
WL-12	17.0 - 19.0	23.0 - 25.0	27.0 - 29.0	-	-	-	-	-
WL-13	33.0 - 35.0	38.0 - 40.0	-	-	-	-	-	-
WL-14	27.0 - 29.0	31.0 - 33.0	-	-	-	-	-	-
WL-15	22.0 - 24.0	36.0 - 38.0	-	-	-	-	-	-
WL-16	14.0 - 16.0	18.0 - 20.0	-	-	-	-	-	-

Table 5.2
Skinner Landfill
Summary of Soil Sample Blank Contamination

Compounds	Range of Detections		Number of Detections in Indicated Sample Series				
			HA	BL	WL	GW	BP
VOLATILES							
ATMOSPHERIC BLANKS							
Acetone	U7 - 110	ug/L	1		5	1	
Chloroform	J2 - 11	ug/L			15	1	
Ethylbenzene	J0.6 - J0.8	ug/L			3		
Methylene Chloride	J3 - 54	ug/L	1	2	6	1	1
Toluene	J0.8 - 12	ug/L			10	1	
Trichloroethene	J0.6	ug/L			1		
Xylene	J2	ug/L			3		
1,1,1-Trichloroethane	J1 - 5	ug/L		1	8		
2-Butanone	J2 - J3	ug/L			2		
2-Hexanone	J3	ug/L			1		
FIELD BLANKS							
Acetone	J0.005 - 0.12	mg/Kg				1	1
Chloroform	J0.005	mg/Kg					1
Methylene Chloride	J0.002 - J0.003	mg/Kg	1	1			
SEMI-VOLATILES							
Benzoic Acid	J0.19	mg/Kg			1		
Benzo(b)Fluoranthene	J0.79	mg/Kg	1				
Diethylphthalate	J0.13 - J0.31	mg/Kg	1		2		
Di-n-Octylphthalate	J0.25	mg/Kg				1	
Hexachlorobenzene	J0.073	mg/Kg			1		
Hexachlorocyclopentadiene	J0.14	mg/Kg			1		
Naphthalene	J0.084	mg/Kg			1		
PESTICIDES							
Chlordane	0.0011	mg/Kg			1		
Hexachlorobenzene	0.00072 - 0.0099	mg/Kg		1		2	
Hexachlorobutadiene	0.001 - 0.025	mg/Kg		1		1	
Octachlorocyclopentene	0.04	mg/Kg		1	1		
1,2,3,4,5,7,7-Heptachlonorborene	0.0015 - 0.0019	mg/Kg			2		
DIOXINS AND FURANS							
Hexa CDF	3.7	ng/Kg			1		
Hepta CDF	9	ng/Kg			1		
Hepta CDD	17	ng/Kg			1		
Octa CDD	125 - 418	ng/Kg			2		

Table 5.3
SKINNER LANDFILL
Summary of WL Series Analytical Results
Including BL Series and GW-27 Samples

Volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Methylene Chloride	6	/	65	0.043	-	5.3	ND
Acetone	8	/	65	0.039	-	140	ND
1,2-Dichloroethene	1	/	65	0.002			ND
Chloroform	5	/	65	0.02	-	33	ND
1,2-Dichloroethane	16	/	65	0.003	-	210	ND
2-Butanone	3	/	65	0.24	-	39	ND
1,1,1-Trichloroethane	4	/	65	0.026	-	63	ND
Carbon Tetrachloride	4	/	65	0.041	-	160	ND
1,2-Dichloropropane	15	/	65	0.14	-	340	ND
Trichloroethene	9	/	65	0.006	-	140	ND
1,1,2-Trichloroethane	17	/	65	0.073	-	370	ND
Benzene	13	/	65	0.007	-	60	ND
Tetrachloroethene	8	/	65	0.049	-	44	ND
1,1,2,2-Tetrachloroethane	6	/	65	0.04	-	130	ND
Toluene	49	/	65	0.001	-	31000	ND
Chlorobenzene	3	/	65	5	-	15	ND
Ethylbenzene	29	/	65	0.0008	-	98	ND
Styrene	3	/	65	0.41	-	25	ND
Xylene (total)	33	/	65	0.001	-	200	ND

Semi-volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Phenol	13	/	71	0.48	-	26	ND
bis(2-Chloroethyl)Ether	8	/	71	0.22	-	21	ND
1,3-Dichlorobenzene	12	/	71	0.043	-	230	ND
1,4-Dichlorobenzene	11	/	71	0.13	-	180	ND
Benzyl Alcohol	7	/	71	0.94	-	9.2	ND
1,2-Dichlorobenzene	9	/	71	0.43	-	94	ND
2-Methylphenol	9	/	71	0.17	-	7.8	ND
4-Methylphenol	9	/	71	0.57	-	26	ND
N-Nitroso-Di-n-Propylamine	1	/	71	0.54			ND
Hexachloroethane	4	/	71	0.69	-	19	ND
Nitrobenzene	2	/	71	0.34	-	23	ND
2,4-Dimethylphenol	3	/	71	0.19	-	1.8	ND
Benzoic Acid	19	/	71	1.6	-	1100	ND
1,2,4-Trichlorobenzene	2	/	71	0.3	-	1.5	ND
Naphthalene	32	/	71	0.11	-	610	ND
Hexachlorobutadiene	10	/	71	0.24	-	68	ND
2-Methylnaphthalene	30	/	71	0.05	-	220	ND
Hexachlorocyclopentadiene	10	/	70	0.4	-	1100	ND

* - Background Locations: GW-35A, GW-35C, GW-35D and GW-35D

ND - Non Detect

Table 5.3 (continued)
SKINNER LANDFILL
Summary of WL Series Analytical Results
Includes BL Series and GW-27 Samples

Semi-volatiles
Units in mg/Kg

	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Dimethyl Phthalate	4	/	71	0.12	-	67	ND
Acenaphthylene	6	/	71	1	-	41	ND
Acenaphthene	11	/	71	0.035	-	7.9	ND
4-Nitrophenol	1	/	71	1.5			ND
Dibenzofuran	8	/	71	0.079	-	7	ND
Fluorene	14	/	71	0.067	-	34	ND
Hexachlorobenzene	15	/	71	0.24	-	480	ND
Phenanthrene	28	/	71	0.058	-	110	ND
Anthracene	9	/	71	0.19	-	84	ND
Di-n-Butylphthalate	12	/	71	0.052	-	15	0.073
Fluoranthene	18	/	71	0.049	-	31	ND
Pyrene	16	/	71	0.12	-	48	ND
Butylbenzylphthalate	13	/	71	0.063	-	25	ND
Benzo(a)Anthracene	10	/	71	0.43	-	15	ND
Chrysene	10	/	71	0.56	-	17	ND
bis(2-Ethylhexyl)Phthalate	22	/	71	0.053	-	150	0.091
Di-n-Octyl Phthalate	5	/	71	3.9	-	10	ND
Benzo(b)Fluoranthene	8	/	71	0.55	-	7	ND
Benzo(k)Fluoranthene	7	/	71	0.29	-	5	ND
Benzo(a)Pyrene	8	/	71	0.38	-	10	ND
Indeno(1,2,3-cd)Pyrene	6	/	70	0.2	-	3.4	ND
Dibenzo(a,h)Anthracene	1	/	71	0.77			ND
Benzo(g,h,i)Perylene	5	/	71	0.16	-	4.1	ND

Pesticides and PCB's
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
beta-BHC	2	/	56	0.0077	-	0.0096	ND
Heptachlor	13	/	56	0.012	-	52	ND
Aldrin	3	/	56	0.64	-	11	ND
Dieldrin	2	/	56	1.7	-	1.9	ND
4,4'-DDD	1	/	56	0.079			ND
4,4'-DDT	1	/	56	0.055			ND
Endrin ketone	7	/	56	0.045	-	84	ND
alpha-Chlordane	1	/	56	8.7			ND
gamma-Chlordane	5	/	56	1.8	-	44	ND
Aroclor-1248	2	/	56	0.55	-	0.78	ND
Aroclor-1260	2	/	56	0.46	-	1.2	ND

* - Background Locations: GW-35A, GW-35C, GW-35D and GW-35D

ND - Non Detect

Table 5.3 (continued)
SKINNER LANDFILL
Summary of WL Series Analytical Results
Includes BL Series and GW-27 Samples

Alternate Pesticide Scan
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Hexachlorobenzene	72	/	84	0.00093	-	1800	0.0038	-	0.0038
Hexachlorocyclopentadiene	17	/	87	0.17	-	4300	0.04	-	0.047
Hexachlorobutadiene	32	/	84	0.0012	-	260	0.0066	-	0.035
Octachlorocyclopentene	23	/	76	0.83	-	23000	0.013		
1,2,3,4,5,7,7-Heptachloronorborene	47	/	83	0.0015	-	2500	0.0017	-	0.019
Chlordene	49	/	82	0.0011	-	1200	0.0016	-	0.0016

Inorganics
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Aluminum	62	/	62	2560	-	225000	11900	-	14600
Antimony	13	/	62	3.4	-	22.3	ND		
Arsenic	62	/	62	2	-	100	2.9	-	5.4
Barium	62	/	62	10.4	-	2900	49.6	-	97.6
Beryllium	38	/	62	0.24	-	2.7	0.34	-	1
Cadmium	6	/	62	1.1	-	56.9	ND		
Calcium	61	/	62	2170	-	263000	3230	-	110000
Chromium	32	/	62	9.6	-	1650	12.1	-	16.4
Cobalt	58	/	62	2	-	22.3	7.8	-	12.1
Copper	44	/	62	6.3	-	566	ND		
Iron	62	/	62	6450	-	45300	17300	-	21300
Lead	48	/	62	6.7	-	4360	10.7	-	17.6
Magnesium	62	/	62	1940	-	61100	2370	-	30500
Manganese	62	/	62	168	-	2430	542	-	1180
Mercury	3	/	62	0.82	-	5.3	ND		
Nickel	51	/	62	4.9	-	130	ND		
Potassium	59	/	59	197	-	6820	1710	-	3040
Selenium	3	/	62	1.1	-	9.3	ND		
Silver	9	/	62	0.72	-	13	ND		
Sodium	40	/	62	152	-	6080	ND		
Thallium	10	/	62	0.24	-	1	ND		
Vanadium	62	/	62	8.2	-	54.1	21.4	-	23.7
Zinc	56	/	62	20.4	-	826	42.8	-	59.1
Cyanide	4	/	62	2.6	-	43.6	ND		

* - Background Locations: GW-35A, GW-35C, GW-35D and GW-35D

ND - Non Detect

Table 5.3 (continued)
SKINNER LANDFILL
Summary of WL Series Analytical Results
Includes BL Series and GW-27 Samples

Dioxins and Furans
Units in ng/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
2,3,7,8-TCDD	2	/	63	27.6	-	29.4	ND
Total TETRA CDD	3	/	63	27.6	-	140.2	ND
Total PENTA CDD	6	/	63	0.8	-	172.7	ND
Total HEXA CDD	4	/	63	19.6	-	189.1	ND
Total HEPTA CDD	4	/	63	105	-	309	ND
Total OCTA CDD	1	/	63	3165	-	3165	ND
2,3,7,8-TCDF	3	/	62	9.6	-	22	ND
Total TETRA CDF	12	/	62	7.4	-	2304.7	ND
Total PENTA CDF	10	/	63	10.3	-	2157.4	ND
Total HEXA CDF	6	/	63	71.7	-	5469.3	ND
Total HEPTA CDF	8	/	63	104	-	3731	ND
Total OCTA CDD	8	/	63	19	-	15109	ND

* - Background Locations: GW-35A, GW-35C, GW-35D and GW-35D

ND - Non Detect

Table 5.4
SKINNER LANDFILL
Summary of BP Area Analytical Results

Volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Acetone	1	/	7	0.09	-	0.09	ND
Chloroform	1	/	7	0.003	-	0.003	ND
Toluene	6	/	7	0.001	-	0.006	ND
Ethylbenzene	3	/	7	0.001			ND
Xylene (total)	3	/	7	0.006	-	0.007	ND

Semi-volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
4-Methylphenol	1	/	7	0.11			ND
Phenanthrene	3	/	7	0.51	-	0.54	ND
Anthracene	2	/	7	0.092		0.092	ND
Di-n-Butylphthalate	1	/	7	0.089			0.073
Fluoranthene	3	/	7	1.1	-	1.2	ND
Pyrene	3	/	7	0.96	-	1.1	ND
Benzo(a)Anthracene	3	/	7	0.42	-	0.59	ND
Chrysene	3	/	7	0.5	-	0.57	ND
bis(2-Ethylhexyl)Phthalate	2	/	7	0.11	-	0.29	0.091
Benzo(b)Fluoranthene	3	/	7	0.81	-	1	ND
Benzo(a)Pyrene	3	/	7	0.4	-	0.65	ND
Indeno(1,2,3-cd)Pyrene	3	/	7	0.29	-	0.34	ND
Benzo(g,h,i)Perylene	3	/	7	0.31	-	0.42	ND

Pesticides
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
4,4'-DDE	1	/	7	0.044			ND
4,4'-DDD	2	/	7	0.01	-	0.11	ND
4,4'-DDT	2	/	7	0.013	-	0.097	ND

* - Background Locations: GW-35A, GW-35C, GW-35D and GW-35E

ND - Non Detect

Table 5.4 (continued)
SKINNER LANDFILL
Summary of BP Area Analytical Results

Alternate Pesticide Scan
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Hexachlorobenzene	1	/	7	0.12	-	0.12	0.0038		
Hexachlorocylopentadiene	0	/	7	ND			0.04	-	0.047
Hexachlorobutadiene	0	/	7	ND			0.0066	-	0.035
Octachlorocyclopentene	0	/	7	ND			0.013		
1,2,3,4,5,7,7-Heptachloronorborene	1	/	7	0.0027	-	0.0027	0.0017	-	0.019
Chlordene	1	/	7	0.0011	-	0.0011	0.0016		

Inorganics
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Aluminum	7	/	7	10600	-	17000	11900	-	14600
Antimony	7	/	7	4.9	-	14.5	ND		
Arsenic	7	/	7	4.5	-	8.9	2.9	-	5.4
Barium	7	/	7	35.3	-	186	49.6	-	97.6
Beryllium	7	/	7	1.2	-	2.3	0.34	-	1
Cadmium	3	/	7	0.54	-	1.4	ND		
Calcium	7	/	7	16300	-	133000	3230	-	110000
Chromium	7	/	7	13.2	-	23.9	12.1	-	16.4
Cobalt	7	/	7	8.2	-	21.2	7.8	-	12.1
Copper	7	/	7	13.5	-	22.4	ND		
Iron	7	/	7	19000	-	39600	17300	-	21300
Lead	7	/	7	3.7	-	207	10.7	-	17.6
Magnesium	7	/	7	3780	-	18600	2370	-	30500
Manganese	7	/	7	639	-	3630	542	-	1180
Mercury	1	/	7	0.26			ND		
Nickel	7	/	7	12.5	-	38.2	ND		
Potassium	7	/	7	1060	-	3070	1710	-	3040
Selenium	1	/	7	0.24			ND		
Silver	7	/	7	2.6	-	4.3	ND		
Sodium	7	/	7	344	-	2540	ND		
Thallium	1	/	7	0.3	-	0.3	ND		
Vanadium	7	/	7	27.8	-	47.1	21.4	-	23.7
Zinc	7	/	7	49	-	131	42.8	-	59.1

* - Background Locations: GW-35A, GW-35C, GW-35D and GW-35E

ND - Non Detect

Table 5.5
SKINNER LANDFILL
Summary of GW Series Analytical Results
Including HA Series, Not Including GW-27

Volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Methylene Chloride	4	/	21	0.064	-	7.9	ND
Acetone	1	/	21	34			ND
2-Butanone	1	/	21	0.045			ND
Tetrachloroethene	5	/	21	0.018	-	2.7	ND
Toluene	6	/	21	0.003	-	0.36	ND
Chlorobenzene	1	/	21	0.002			ND
Ethylbenzene	1	/	21	0.002			ND
Xylene (total)	7	/	21	0.001	-	0.016	ND

Semi-volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
4-Methylphenol	1	/	19	0.14			ND
Isophorone	1	/	19	0.21			ND
Benzoic Acid	2	/	19	0.1	-	0.19	ND
Naphthalene	1	/	19	0.22			ND
2-Methylnaphthalene	1	/	19	0.064			ND
Diethylphthalate	1	/	19	0.078			ND
Hexachlorobenzene	2	/	19	0.091	-	0.62	ND
Phenanthrene	3	/	19	0.085	-	0.093	ND
Di-n-Butylphthalate	6	/	19	0.055	-	0.3	0.073
Fluoranthene	4	/	19	0.15	-	0.2	ND
Pyrene	4	/	19	0.13	-	0.21	ND
Butylbenzylphthalate	2	/	19	0.43	-	0.48	ND
Benzo(a)Anthracene	4	/	19	0.069	-	0.12	ND
Chrysene	4	/	19	0.08	-	0.16	ND
bis(2-Ethylhexyl)Phthalate	7	/	19	0.045	-	12	0.091
Di-n-Octyl Phthalate	1	/	19	0.96			ND
Benzo(k)Fluoranthene	2	/	19	0.05	-	0.087	ND
Benzo(a)Pyrene	2	/	19	0.062	-	0.15	ND
Dibenzo(a,h)Anthracene	1	/	19	0.41			ND

Pesticides
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Detected Concentrations*
Endrin	2	/	20	0.61	-	0.65	ND
Aroclor-1254	5	/	20	0.14	-	1.4	ND

* - Background Locations: GW-35A, GW-35C, GW-35D, GW-35E

Table 5.5 (continued)
SKINNER LANDFILL
Summary of GW Series Analytical Results
Including HA Series, Not Including GW-27

Alternate Pesticide Scan
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations		Range of Background Concentrations*	
Hexachlorobenzene	2 /	19	0.073 -	0.077	0.0038	
Hexachlorocylopentadiene	0 /	19	ND		0.04 -	0.047
Hexachlorobutadiene	2 /	19	0.0017 -	0.0041	0.0066 -	0.035
Octachlorocyclopentene	0 /	19	ND		0.013	
1,2,3,4,5,7,7-Heptachloronorborene	2 /	19	0.0011 -	0.0017	0.0017 -	0.019
Chlordene	0 /	19	ND		0.0016	

Inorganics
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations		Range of Background Concentrations*	
Aluminum	19 /	19	2450 -	18100	11900 -	14600
Antimony	2 /	19	13.1 -	14.9	ND	
Arsenic	18 /	19	3.3 -	10.7	2.9 -	5.4
Barium	18 /	19	24.3 -	166	49.6 -	97.6
Beryllium	15 /	19	0.33 -	0.94	0.34 -	1
Cadmium	3 /	19	1 -	1.9	ND	
Calcium	19 /	19	9090 -	191000	3230 -	110000
Chromium	17 /	19	7.5 -	97	12.1 -	16.4
Cobalt	16 /	19	3.1 -	13.4	7.8 -	12.1
Copper	7 /	19	22.6 -	73	ND	
Iron	19 /	19	6980 -	48300	17300 -	21300
Lead	19 /	19	5.5 -	169	10.7 -	17.6
Magnesium	19 /	19	3000 -	63200	2370 -	30500
Manganese	19 /	19	337 -	1830	542 -	1180
Mercury	7 /	19	0.1 -	1	ND	
Nickel	4 /	19	28.1 -	44.3	ND	
Potassium	19 /	19	620 -	2960	1710 -	3040
Silver	2 /	19	0.54 -	1.1	ND	
Sodium	7 /	19	86.8 -	187	ND	
Thallium	6 /	19	0.26 -	0.48	ND	
Vanadium	19 /	19	8 -	32.1	21.4 -	23.7
Zinc	18 /	19	36.2 -	288	42.8 -	59.1

Dioxins and Furans
Units in ng/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations		Range of Background Concentrations*	
Total HEPTA CDD	2 /	8	1 -	205	ND	
Total OCTA CDD	1 /	8	192		ND	
2,3,7,8-TCDF	1 /	8	8		ND	
Total TETRA CDF	1 /	8	8		ND	

* - Background Locations: GW-35A, GW-35C, GW-35D, GW-35E

Table 5.6
Summary Field Measurement Data
Skinner Landfill
Ground Water Samples

Location ID	Specific Conductivity (uhmos/cm)	Average Values pH Measured (Std. Units)	Temparature (deg. C)	Location ID	Specific Conductivity (uhmos/cm)	Average Values pH Measured (Std. Units)	Temparature (deg. C)
Unconsolidated Sediment Water				Bedrock Water			
B5	1371	7.08	12.6	WW09	988	7.15	13.9
B8	652	8.05	11.7	WW17	1483	6.70	16.0
WW06	687	9.51	13.5	WW18	1550	6.67	17.4
WW07	915	7.25	11.6	WW24	751	7.10	11.3
WW10	1603	7.46	15.4	WW26	1222	8.27	14.0
WW11	1872	7.07	13.1	WW27	968	7.25	13.3
WW12	1938	7.01	12.7	WW28	1851	8.33	11.5
WW14	422	7.68	10.7	WW29	553	7.38	11.1
WW15	1019	6.77	12.5	WW30	951	7.38	11.2
WW19	896	7.19	13.1	WW31	960	7.56	11.2
WW20	2293	6.73	13.4	WW32	2245	7.56	14.4
WW23	677	7.39	12.2	WW35	4713	7.50	14.0
WW33	897	7.29	14.0	WW38	1102	7.85	12.8
WW36	1407	7.24	12.1				
Average	1189	7.41	12.8	Average	1487	7.44	13.2
Minimum	422	6.73	10.7	Minimum	553	6.67	11.1
Maximum	2293	9.51	15.4	Maximum	4713	8.33	17.4

Table 5.7
Skinner Landfill
Summary of Ground Water Blank Contamination

Compounds	Range of Detections				Number of Detections in Indicated Sample Series	
					WW	RW
Volatile Organic						
Acetone	U9	-	17	ug/L	3	
Carbon Disulfide	0.8			ug/L	2	
Chloroform	J2	-	10	ug/L	22	
Ethylbenzene	J1			ug/L	2	
Methylene Chloride	U10	-	85	ug/L	11	1
Toluene	J1	-	10	ug/L	9	
Xylene	J0.4	-	7	ug/L	4	
1,1,1-Trichloroethane	J0.9	-	8	ug/L	14	
2-Hexanone	J6			ug/L	1	
Pesticides						
1,2,3,4,5,7,7-Heptachloronorborene	0.0079			ug/L	2	

Table 5.8
SKINNER LANDFILL
Summary of Area Analytical Results
Unconsolidated Sediment Wells

Volatiles
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Vinyl Chloride	3	/	15	8	-	48	ND
Chloroethane	2	/	15	50	-	52	ND
1,1-Dichloroethane	3	/	15	52	-	82	ND
1,2-Dichloroethene	4	/	15	5	-	35	ND
Chloroform	1	/	15	85			ND
1,2-Dichloroethane	4	/	15	5	-	180	ND
2-Butanone	1	/	15	12			ND
1,2-Dichloropropane	3	/	15	21	-	370	ND
Trichloroethene	2	/	15	2	-	71	ND
1,1,2-Trichloroethane	1	/	15	55			ND
Benzene	4	/	15	1	-	490	ND
Tetrachloroethene	1	/	15	3			ND
1,1,2,2-Tetrachloroethane	1	/	15	6			ND
Chlorobenzene	2	/	15	1	-	4	ND
Ethylbenzene	3	/	15	7	-	24	ND

Semi-volatiles
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
bis(2-Chloroethyl)Ether	4	/	16	1	-	130	ND
2-Chlorophenol	1	/	16	1			ND
1,3-Dichlorobenzene	1	/	16	13	-	13	ND
1,4-Dichlorobenzene	1	/	16	10	-	10	ND
Benzyl Alcohol	1	/	16	1			ND
1,2-Dichlorobenzene	1	/	16	6	-	6	ND
bis(2-Chloroisopropyl)Ether	1	/	16	2	-	2	ND
Benzoic Acid	3	/	16	5	-	2700	ND
Naphthalene	2	/	16	2	-	14	ND
Diethylphthalate	1	/	16	3			ND
Phenanthrene	1	/	16	11			ND
bis(2-Ethylhexyl)Phthalate	1	/	16	1			ND

Pesticides
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Aldrin	1	/	15	0.5			ND

* - Background Locations: WW-23 and WW-36

ND - Non Detect

Table 5.8 (continued)
SKINNER LANDFILL
Summary of Area Analytical Results
Unconsolidated Sediment Wells

Alternate Pesticides
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Hexachlorobenzene	1	/	14	0.2			ND		
Hexachlorobutadiene	2	/	14	0.015	-	0.019	ND		
1,2,3,4,5,7,7-Heptachloronorborene	2	/	14	0.052	-	0.089	ND		

Inorganics
Units in mg/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Aluminum	1	/	15	0.191			0.034		
Arsenic	7	/	15	0.002	-	0.0612	ND		
Barium	15	/	15	0.031	-	5.95	0.03	-	0.05
Beryllium	0	/	15	ND			0.0039	-	0.0039
Cadmium	1	/	15	0.0025			ND		
Calcium	15	/	15	14.3	-	269	103.5	-	112
Chromium	0	/	15	ND			0.01		
Cobalt	0	/	15	ND			0.0061	-	0.0061
Copper	9	/	15	0.004	-	0.0105	0.013		
Iron	3	/	15	4.23	-	19	0.009	-	0.018
Magnesium	15	/	15	8.08	-	76.6	31.63	-	35.8
Manganese	13	/	15	0.0346	-	1.93	0.021	-	0.074
Mercury	4	/	15	0.0002	-	0.0029	ND		
Nickel	3	/	15	0.012	-	0.0219	0.01		
Potassium	14	/	15	1.59	-	42	2.63		
Sodium	15	/	15	2.89	-	145	8.857	-	12.3
Vanadium	13	/	15	0.0043	-	0.0154	ND		
Zinc	4	/	15	0.0376	-	0.0833	0.016		
Cyanide	1	/	15	0.0235			ND		

* - Background Locations: WW-23 and WW-36

ND - Non Detect

Table 5.9
SKINNER LANDFILL
Summary of Area Analytical Results
Bedrock Wells

Volatiles
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Carbon Disulfide	1	/	13	35			ND
Benzene	2	/	13	690	-	890	ND
Chlorobenzene	2	/	13	24	-	27	ND
Ethylbenzene	1	/	13	5			ND

Semi-volatiles
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Phenol	3	/	14	2	-	13	ND
1,4-Dichlorobenzene	2	/	14	8	-	11	ND
Naphthalene	1	/	14	2			ND

Alternate Pesticides
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations	Range of Background Concentrations*
Hexachlorobenzene	1	/	14	0.24	ND
Hexachlorocyclopentadiene	1	/	14	0.065	ND
Hexachlorobutadiene	1	/	14	0.087	ND
1,2,3,4,5,7,7-Heptachloronorborene	1	/	14	0.11	ND
Chlordene	1	/	14	0.057	ND

* - Background Location: WW-35

ND - Non Detect

Table 5.9 (continued)
SKINNER LANDFILL
Summary of Area Analytical Results
Bedrock Wells

Inorganics
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Aluminum	1	/	14	0.017			ND
Arsenic	2	/	14	0.0423	-	0.0497	ND
Barium	14	/	14	0.026	-	0.795	0.626
Cadmium	1	/	14	0.0037			ND
Calcium	14	/	14	28.4	-	112	88
Chromium	3	/	14	0.004	-	0.023	ND
Copper	8	/	14	0.003	-	0.009	ND
Iron	4	/	14	0.493	-	19.1	ND
Magnesium	14	/	14	12.9	-	39	36.2
Manganese	14	/	14	0.016	-	1.43	0.0719
Mercury	2	/	14	0.00026	-	0.0004	ND
Potassium	14	/	14	1.62	-	51.5	22.6
Sodium	14	/	14	3.72	-	348	790
Vanadium	5	/	14	0.004	-	0.0138	0.0057

* - Background Location: WW-35

ND - Non Detect

Table 5.10
Skinner Landfill
Summary of Leachate, Surface Water and Sediment Blank Contamination

Compounds	Range of Detections				Number of Detections in Indicated Sample Series			
					LW	LS	SF	SM
VOLATILES								
ATMOSPHERIC BLANKS								
Acetone	J4	-	65	ug/L	4	2	9	
Chloroform	J3	-	14	ug/L	7	1	17	
Methylene Chloride	5	-	12	ug/L	5		30	
Tetrachlorethene	J1	-	9	ug/L			5	
Toluene	0.8	-	J2	ug/L	6		3	
1,1,1-Trichloroethane	J0.9	-	J2	ug/L	4		3	
2-Butanone	J8			ug/L			1	
FIELD BLANKS								
Methylene Chloride	J0.004	-	12	mg/Kg				3
SEMI-VOLATILES								
ATMOSPHERIC BLANKS								
bis(2-Ethylhexyl)Phthalate	J1			ug/L			1	
Chrysene	10			ug/L			1	
N-Nitrosodiphenylamine(1)	J1			ug/L			1	1
FIELD BLANKS								
Butylbenzylphthalate	J0.058			mg/Kg				1
Diethylphthalate	J0.1			mg/Kg				1
N-Nitrosodiphenylamine(1)	J0.11			mg/Kg				1
PESTICIDES								
ATMOSPHERIC BLANKS								
1,2,3,4,5,7,7-Heptachloronorborene	0.0082	-	0.012	ug/L	1		2	
FIELD BLANKS								
Hexachlorobenzene	0.0004			mg/Kg				1

Table 5.11
Summary of Field Measurement Data
Skinner Landfill
Surface Water, Sediment and Leachate Samples

Location ID	Specific Conductivity (uhmos/cm)	Average Values pH Measured (Std. Units)	Temperature (deg. C)	Sediment HNu/OVA/ OVM (ppm)
Mill Creek				
SF01	758	7.73	7.9	0
SF02	795	7.77	6.1	0
SF03	776	8.35	6.1	0
SF04	799	8.44	5.6	0
SF05	759	8.34	6.5	0
SF06	767	8.41	7.4	0
SF07	785	8.45	7.7	0
SF08	699	7.89	13.0	0
SF09	720	8.14	14.2	0
SF10	691	8.22	14.3	0
SF11	710	8.44	13.4	0
SF12	705	8.44	14.2	0
SF13	688	8.54	6.3	0
SF14	656	8.64	7.4	0
SF15	649	8.51	9.8	0
SF36	704	8.85	6.4	-
Avg	729	8.32	9.1	
Min	649	7.73	5.6	
Max	799	8.85	14.3	
Dump Creek				
SF16	1092	7.87	10.6	0
SF17	883	7.42	8.4	0
SF18	648	7.27	8.9	0
SF19	600	7.52	8.7	0
Avg	806	7.52	9.1	
Min	600	7.27	8.4	
Max	1092	7.87	10.6	

Table 5.11 (continued)
Summary of Field Measurement Data
Skinner Landfill
Surface Water, Sediment and Leachate Samples

Location ID	Specific Conductivity (uhmos/cm)	Average Values pH Measured (Std. Units)	Temperature (deg. C)	Sediment HNu/OVA/ OVM (ppm)
Skinner Creek				
SF20	964	8.39	4.3	0
SF21	954	8.39	6.3	0
SF22	866	7.88	6.2	0
SF23	893	8.09	7.4	0
SF24	920	8.32	7.2	0
SF25	968	8.56	5.7	0
SF26	970	8.59	5.9	0
SF37	914	8.10	6.1	-
Avg	931	8.29	6.1	
Min	866	7.88	4.3	
Max	970	8.59	7.4	
Duck Pond				
SF27	192	7.53	19.5	0
SF28	177	7.13	21.3	0
SF29	190	7.23	23.2	0
Avg	185	7.30	21.3	
Min	177	7.13	19.5	
Max	192	7.53	23.2	
Diving Pond				
SF30	272	9.31	11.5	1
SF31	219	9.44	12.3	11.4
SF32	228	8.89	12.3	1
Avg	240	9.22	12.0	
Min	219	8.89	11.5	
Max	272	9.44	12.3	

Table 5.11 (continued)
Summary of Field Measurement Data
Skinner Landfill
Surface Water, Sediment and Leachate Samples

Location ID	Specific Conductivity (uhmos/cm)	Average Values pH Measured (Std. Units)	Temperature (deg. C)	Sediment HNu/OVA/ OVM (ppm)
		Trilobite Pond		
SF33A	622	7.75	12.9	0
SF33B	621	7.83	11.7	0
SF34A	630	8.03	12.9	0
SF34B	618	8.11	12.9	0
SF35A	607	8.23	12.1	0
SF35B	590	8.15	11.9	0
Avg	615	8.02	12.4	
Min	590	7.75	11.7	
Max	630	8.23	12.9	
		Mill Creek		
LW01	2020	7.13	12.7	0
LW02	2442	7.39	10.0	0
Avg	2231	7.26	11.4	
Min	2020	7.13	10.0	
Max	2442	7.39	12.7	
		Skinner Creek		
LW03	741	7.07	11.6	0

Table 5.12
SKINNER LANDFILL
Summary of Area Analytical Results
Mill Creek

Volatiles
Units in ug/L

Compound Name	Detections	Samples	Range of Detected Concentrations	Range of Background Concentrations*
Xylene (total)	1 /	13	3 - 3	ND

Semi-volatiles
Units in ug/L

Compound Name	Detections	Samples	Range of Detected Concentrations	Range of Background Concentrations*
Diethylphthalate	2 /	13	2 - 4	ND
Di-n-Butylphthalate	6 /	13	1 - 10	3 - 13

Alternate Pesticide Scan
Units in ug/L

Compound Name	Detections	Samples	Range of Detected Concentrations	Range of Background Concentrations*
Hexachlorobenzene	0 /	13	ND	0.023

Inorganics
Units in mg/L

Compound Name	Detections	Samples	Range of Detected Concentrations	Range of Background Concentrations*
Antimony	0 /	12	ND	0.0228
Barium	12 /	12	0.0412 - 0.0683	0.0324 - 0.044
Cadmium	1 /	12	0.0031	0.0037
Calcium	12 /	12	85.9 - 104	10.3 - 88.1
Cobalt	1 /	12	0.0056 - 0.0056	ND
Iron	6 /	12	0.138 - 0.425	0.161 - 0.616
Magnesium	12 /	12	23.3 - 29.3	25.9 - 29.3
Manganese	7 /	12	0.0058 - 0.0133	0.0038 - 0.0184
Nickel	1 /	12	0.0078	ND
Potassium	12 /	12	2.18 - 3.38	1.36 - 2.59
Selenium	1 /	12	0.0012	ND
Silver	3 /	12	0.0032 - 0.0044	ND
Sodium	12 /	12	17.2 - 27.2	19.2 - 21
Thallium	0 /	12	ND	0.0014
Vanadium	1 /	12	0.0098	ND

* - Background Locations: SF-12, SF-13, SF-14 and SF-15

ND - Non Detect

Table 5.13
SKINNER LANDFILL
Summary of Area Analytical Results
Mill Creek Sediments

Volatiles
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Acetone	2 /	12	0.007	-	0.016	0.036	-	0.11
1,2-Dichloroethene	0 /	12	ND			0.004		

Semi-volatiles
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Naphthalene	2 /	13	0.022	-	0.38	ND		
2-Methylnaphthalene	1 /	13	0.045			ND		
Acenaphthylene	2 /	13	0.076	-	0.12	ND		
Acenaphthene	1 /	13	0.4			ND		
Dibenzofuran	3 /	13	0.042	-	0.28	ND		
Fluorene	6 /	13	0.04	-	0.39	ND		
Phenanthrene	11 /	13	0.12	-	2.9	0.1	-	0.13
Anthracene	7 /	13	0.047	-	0.58	ND		
Fluoranthene	13 /	13	0.11	-	3.3	0.12	-	0.2
Pyrene	11 /	13	0.18	-	3.2	0.13	-	0.21
Benzo(a)Anthracene	11 /	13	0.097	-	1.6	0.093		
Chrysene	10 /	13	0.11	-	1.9	0.089	-	0.1
bis(2-Ethylhexyl)Phthalate	7 /	13	0.043	-	0.18	0.23		
Di-n-Octyl Phthalate	0 /	13	ND			0.15		
Benzo(b)Fluoranthene	12 /	13	0.067	-	1.7	0.11	-	0.13
Benzo(k)Fluoranthene	10 /	13	0.067	-	1.2	ND		
Benzo(a)Pyrene	10 /	13	0.069	-	1.4	ND		
Indeno(1,2,3-cd)Pyrene	8 /	13	0.099	-	0.61	ND		
Dibenzo(a,h)Anthracene	3 /	13	0.055	-	0.13	ND		
Benzo(g,h,i)Perylene	9 /	13	0.078	-	0.51	ND		

Pesticides
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations	Range of Background Concentrations*
beta-BHC	1 /	13	0.028	ND
4,4'-DDD	1 /	13	0.0038	ND
alpha-Chlordane	1 /	13	0.0042	ND
Aroclor-1254	1 /	13	0.16	ND

* - Background Locations: SM-12, SM-13, SM-14 and SM-15

ND - Non Detect

Table 5.13 (continued)
SKINNER LANDFILL
Summary of Area Analytical Results
Mill Creek Sediments

Alternate Pesticide Scan
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Hexachlorobenzene	9	/	12	0.0029	-	0.016	0.0045		
Hexachlorocyclopentadiene	0	/	12	ND			0.044	-	0.069
Hexachlorobutadiene	1	/	12	0.0019	-	0.0019	0.0018	-	0.12
Octachlorocyclopentene	1	/	12	0.012	-	0.012	0.0015	-	0.014
1,2,3,4,5,7,7-Heptachloronorborene	0	/	12	ND			0.0013	-	0.026
Chlordene	5	/	12	0.0013	-	0.0034	0.0034	-	0.006

Inorganics
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Aluminum	12	/	12	2990	-	10900	4870	-	13600
Antimony	2	/	12	4.4	-	8.9	3.9		
Arsenic	12	/	12	4.1	-	3090	2.7	-	9.1
Barium	12	/	12	43.1	-	268	62.2	-	189
Beryllium	10	/	12	0.28	-	0.74	0.41	-	1.1
Cadmium	0	/	12	ND			0.96	-	4.6
Calcium	12	/	12	16100	-	211000	16400	-	163000
Chromium	10	/	12	9.3	-	13.2	7.9	-	19.4
Cobalt	9	/	12	5.5	-	20.9	5.6	-	22.6
Copper	2	/	12	17.6	-	19.8	18.8	-	18.8
Iron	12	/	12	9250	-	22300	12100	-	27800
Lead	12	/	12	10	-	26	10.5	-	23.6
Magnesium	12	/	12	11200	-	38000	4440	-	29700
Manganese	12	/	12	631	-	3520	805	-	3250
Mercury	8	/	12	0.12	-	0.13	ND		
Nickel	12	/	12	8.9	-	21.9	10.6	-	22.4
Potassium	12	/	12	730	-	2230	1300	-	2500
Selenium	3	/	12	9.7	-	15.8	ND		
Silver	1	/	12	1.4			ND		
Thallium	4	/	12	0.27	-	0.47	0.29	-	0.36
Vanadium	11	/	12	8.2	-	23.5	12.8	-	35.5
Zinc	12	/	12	26.1	-	172	30.2	-	56.2

* - Background Locations: SM-12, SM-13, SM-14 and SM-15

ND - Non Detect

Table 5.14
SKINNER LANDFILL
Summary of Area Analytical Results
Skinner Creek

Semi-volatiles
Units in ug/L

Compound Name	Detections	Samples	Range of Detected Concentrations	Range of Background Concentrations*
Phenol	1 /	8	3 - 3	ND
Diethylphthalate	2 /	8	1 - 3	ND
Butylbenzylphthalate	1 /	8	3 - 3	ND

Alternate Pesticide Scan
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations	Range of Background Concentrations*
1,2,3,4,5,7,7-Heptachloronorborene	0 /	8	ND	0.15

Inorganics
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations	Range of Background Concentrations*
Antimony	2 /	8	0.022 - 0.0269	0.032
Barium	8 /	8	0.0329 - 0.0362	0.0336
Cadmium	2 /	8	0.0031 - 0.0048	0.0059
Calcium	8 /	8	118 - 129	131
Iron	2 /	8	0.196 - 0.264	ND
Magnesium	8 /	8	25.5 - 29.2	29.6
Manganese	8 /	8	0.0163 - 0.0715	0.0094
Nickel	2 /	8	0.0098 - 0.0106	0.0075
Potassium	8 /	8	2.33 - 2.89	2.62
Silver	0 /	8	ND	0.0032
Sodium	8 /	8	44.3 - 51.3	51.5
Vanadium	3 /	8	0.0014 - 0.0098	0.0091

* - Background Location: SF-26

ND - Non Detect

Table 5.15
SKINNER LANDFILL
Summary of Area Analytical Results
Skinner Creek Sediments

Volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Acetone	2	/	7	0.023	-	0.062	ND
1,2-Dichloroethene	1	/	7	0.083			ND
Trichloroethene	1	/	7	0.02			ND

Semi-volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Acenaphthene	1	/	7	0.14			ND
Dibenzofuran	1	/	7	0.13			ND
Fluorene	1	/	7	0.22			ND
Phenanthrene	2	/	7	0.51	-	1.8	0.3
Anthracene	1	/	7	0.31			0.12
Di-n-Butylphthalate	5	/	7	0.073	-	0.16	ND
Fluoranthene	5	/	7	0.09	-	2.5	1
Pyrene	5	/	7	0.09	-	1.5	0.73
Benzo(a)Anthracene	2	/	7	0.32	-	0.68	0.46
Chrysene	4	/	7	0.056	-	0.69	0.43
Benzo(b)Fluoranthene	2	/	7	0.42	-	0.51	0.37
Benzo(k)Fluoranthene	2	/	7	0.26	-	0.51	0.35
Benzo(a)Pyrene	1	/	7	0.33	-	0.33	0.28
Indeno(1,2,3-cd)Pyrene	1	/	7	0.26			0.19
Dibenzo(a,h)Anthracene	0	/	7	ND			0.068
Benzo(g,h,i)Perylene	2	/	7	0.19	-	0.21	ND

Alternate Pesticide Scan
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Hexachlorobenzene	2	/	7	0.003	-	0.003	ND
Hexachlorocyclopentadiene	3	/	7	0.052	-	0.067	ND
Hexachlorobutadiene	6	/	7	0.0021	-	0.027	0.0067
1,2,3,4,5,7,7-Heptachloronorborene	3	/	7	0.0012	-	0.029	0.0014
Chlordene	4	/	7	0.0013	-	0.0049	ND

* - Background Location: SM-28

ND - Non Detect

Table 5.15 (continued)
SKINNER LANDFILL
Summary of Area Analytical Results
Skinner Creek Sediments

Inorganics
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Aluminum	7	/	7	9020	-	15900	9040
Arsenic	7	/	7	6.9	-	9.7	7.2
Barium	7	/	7	87.8	-	156	69.9
Beryllium	7	/	7	0.31	-	0.81	0.7
Cadmium	2	/	7	0.31	-	0.32	ND
Calcium	7	/	7	47900	-	107000	89300
Chromium	7	/	7	11.1	-	20	16.8
Cobalt	7	/	7	9.8	-	17.7	7.5
Copper	2	/	7	17.4	-	18.2	ND
Iron	7	/	7	18700	-	25700	19900
Lead	7	/	7	29.9	-	139	30.2
Magnesium	7	/	7	5260	-	18700	6920
Manganese	7	/	7	1140	-	2370	1230
Nickel	7	/	7	17.2	-	50.5	25.1
Potassium	7	/	7	1500	-	2840	1620
Vanadium	6	/	7	22.7	-	32.3	20.5
Zinc	7	/	7	50.7	-	79.3	74

* - Background Location: SM-26

ND - Non Detect

Table 5.16
SKINNER LANDFILL
Summary of Area Analytical Results
Dump Creek and Duck Pond Water Samples

Semi-volatiles
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
bis(2-Chloroisopropyl)Ether	1	/	6	3			ND
Di-n-Butylphthalate	1	/	6	2			ND
Pyrene	1	/	6	1			ND

Inorganics
Units in mg/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Aluminum	3	/	6	0.758	-	3.33	27.7
Barium	3	/	6	0.0445	-	0.0522	0.174
Cadmium	1	/	6	0.003			ND
Calcium	6	/	6	22.7	-	161	118
Cobalt	0	/	6	ND			0.0164
Iron	6	/	6	0.523	-	4.7	39.7
Lead	0	/	6	ND			0.0336
Magnesium	6	/	6	4.08	-	35.4	30
Manganese	6	/	6	0.0288	-	0.565	1.02
Nickel	1	/	6	0.012			0.0391
Potassium	6	/	6	1.56	-	6.7	5.46
Selenium	1	/	6	0.001			ND
Sodium	6	/	6	1.53	-	26.3	7.82
Vanadium	1	/	6	0.0056			0.0489
Zinc	0	/	6	ND			0.163

* - Background Location: SF-18

ND - Non Detect

Table 5.17
SKINNER LANDFILL
Summary of Area Analytical Results
Dump Creek and Duck Pond Sediments

Volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Acetone	1	/	6	0.074			0.023
Toluene	0	/	6	ND			0.009

Semi-volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Naphthalene	1	/	6	0.18			ND
2-Methylnaphthalene	2	/	6	0.12	-	0.16	ND
Dibenzofuran	1	/	6	0.15			ND
Fluorene	1	/	6	0.22			ND
Phenanthrene	2	/	6	0.16	-	2	ND
Anthracene	1	/	6	0.51			ND
Di-n-Butylphthalate	1	/	6	0.071			ND
Fluoranthene	2	/	6	0.13	-	1.9	ND
Pyrene	2	/	6	0.14	-	1.9	ND
Benzo(a)Anthracene	1	/	6	0.83			ND
Chrysene	1	/	6	0.88			ND
bis(2-Ethylhexyl)Phthalate	2	/	6	0.08	-	0.57	ND
Benzo(b)Fluoranthene	2	/	6	0.11	-	1.1	ND
Benzo(k)Fluoranthene	1	/	6	0.16			ND
Benzo(a)Pyrene	1	/	6	0.74			ND

Alternate Pesticide Scan
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Hexachlorobenzene	1	/	6	0.0032			ND
Hexachlorobutadiene	1	/	6	0.0025			ND
1,2,3,4,5,7,7-Heptachloronorborene	2	/	6	0.0017	-	0.0025	ND
Chlordene	1	/	6	0.00161			ND

* - Background Location: SM-18

ND - Non Detect

Table 5.17 (continued)
SKINNER LANDFILL
Summary of Area Analytical Results
Dump Creek and Duck Pond Sediments

Inorganics
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*
Aluminum	6	/	6	8590	-	24900	13600
Arsenic	6	/	6	6.6	-	9.2	6.5
Barium	6	/	6	56.5	-	209	189
Beryllium	6	/	6	0.39	-	0.9	0.41
Cadmium	3	/	6	0.84	-	1.3	0.96
Calcium	5	/	6	4750	-	34000	16400
Chromium	6	/	6	10.1	-	29.7	19.4
Cobalt	6	/	6	6.2	-	18.7	22.6
Copper	6	/	6	17.5	-	29.3	18.8
Iron	6	/	6	16700	-	26900	27800
Lead	6	/	6	15.9	-	44.1	23.6
Magnesium	6	/	6	2810	-	9810	4440
Manganese	6	/	6	704	-	2830	3250
Nickel	6	/	6	12.9	-	24	22.4
Potassium	6	/	6	1360	-	3160	1740
Thallium	5	/	6	0.34	-	0.61	ND
Vanadium	6	/	6	19.9	-	54.6	31.6
Zinc	6	/	6	46.1	-	114	56.2

* - Background Location: SM-18

ND - Non Detect

Table 5.18
SKINNER LANDFILL
Summary of Area Analytical Results
Diving and Trilobite Ponds

Semi-volatiles
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Phenol	1	/	10	1			ND		
Dimethyl Phthalate	1	/	10	1			ND		
Diethylphthalate	2	/	10	1	-	2	ND		

Alternate Pesticide Scan
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Hexachlorobenzene	1	/	10	0.033			ND		
Hexachlorobutadiene	4	/	10	0.0029	-	0.011	ND		

Inorganics
Units in ug/L

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Aluminum	6	/	10	1.02	-	4.61	0.758	-	0.758
Antimony	2	/	10	0.0253	-	0.0535	ND		
Barium	6	/	10	0.0311	-	0.0438	ND		
Cadmium	6	/	10	0.0037	-	0.0058	ND		
Calcium	10	/	10	23.8	-	84.3	27.4	-	24
Iron	10	/	10	0.179	-	2.88	0.523	-	1.06
Magnesium	10	/	10	13.9	-	25.4	4.08	-	4.35
Manganese	10	/	10	0.018	-	0.0536	0.0623	-	0.144
Nickel	4	/	10	0.0059	-	0.0084	ND		
Potassium	10	/	10	1.15	-	4.39	2.18	-	2.81
Selenium	0	/	10	ND			0.001	-	0.001
Sodium	10	/	10	1.61	-	15.1	1.53	-	1.78
Vanadium	9	/	10	0.006	-	0.0104	ND		

* - Background Loctions: SF-27, SF-28 and SF-29

ND - Non Detect

Table 5.19
SKINNER LANDFILL
Summary of Area Analytical Results
Diving and Trilobite Pond Sediments

Volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
2-Butanone	2	/	7	0.005	-	0.011	ND		
Xylene (total)	3	/	7	0.008	-	0.038	ND		

Semi-volatiles
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Naphthalene	1	/	12	0.14			ND		
2-Methylnaphthalene	5	/	12	0.18	-	0.49	ND		
Acenaphthene	2	/	12	0.13	-	0.16	ND		
Fluorene	3	/	12	0.1	-	0.14	ND		
Phenanthrene	6	/	12	0.12	-	0.59	ND		
Fluoranthene	4	/	12	0.12	-	0.14	ND		
Pyrene	6	/	12	0.18	-	0.42	ND		
Benzo(a)Anthracene	2	/	12	0.099	-	0.1	ND		
Chrysene	2	/	12	0.11	-	0.14	ND		
bis(2-Ethylhexyl)Phthalate	1	/	12	0.26			0.08		
Benzo(b)Fluoranthene	1	/	12	0.16			ND		

PCB's
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Aroclor-1254	4	/	7	0.2	-	0.29	ND		
Aroclor-1260	4	/	7	0.25	-	0.43	ND		

Alternate Pesticide Scan
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Hexachlorobenzene	2	/	7	0.0049	-	0.0072	0.0032		
Hexachlorobutadiene	2	/	7	0.0023	-	0.0034	ND		
1,2,3,4,5,7,7-Heptachloronorborene	3	/	7	0.0017	-	0.0037	0.0017	-	0.0025
Chlordene	0	/	7	ND			0.00161	-	0.00161

* - Background Locations: SM-27, SM-28 and SM-29

ND - Non Detect

Table 5.19 (continued)
SKINNER LANDFILL
Summary of Area Analytical Results
Diving and Trilobite Pond Sediments

Inorganics
Units in mg/Kg

Compound Name	Detections		Samples	Range of Detected Concentrations			Range of Background Concentrations*		
Aluminum	7	/	7	13400	-	42700	18600	-	24900
Arsenic	7	/	7	2.2	-	5.9	6.6	-	9.2
Barium	7	/	7	48.2	-	137	136	-	209
Beryllium	7	/	7	0.77	-	2.3	0.64	-	0.9
Calcium	7	/	7	41900	-	87500	4750	-	7180
Chromium	7	/	7	17.8	-	46.4	21.3	-	29.7
Cobalt	7	/	7	6.4	-	21.6	15.7	-	18.7
Copper	5	/	7	16.9	-	22.7	21.1	-	29.3
Iron	7	/	7	25300	-	39000	22800	-	26900
Lead	7	/	7	10.4	-	401	25.1	-	37.7
Magnesium	7	/	7	10300	-	16200	2810	-	3580
Manganese	7	/	7	470	-	638	922	-	2830
Nickel	7	/	7	14.4	-	39.3	19.9	-	24
Potassium	7	/	7	3090	-	16000	2030	-	3160
Thallium	0	/	7	ND			0.42	-	0.61
Vanadium	7	/	7	21.7	-	73.3	38.7	-	54.6
Zinc	7	/	7	72.3	-	125	68.1	-	89.2

* - Background Locations: SM-27, SM-28 and SM-29

ND - Non Detect

Table 5.20
SKINNER LANDFILL
Summary of Area Analytical Results
Leachate Water Samples

Volatiles
Units in ug/L

Compound Name	Detections	Samples	Range of Detected Concentrations			Detection Locations
Chloroethane	2 /	4	9	-	9	LW-01, LW-01DP
1,1-Dichloroethane	2 /	4	2	-	2	LW-01, LW-01DP
Benzene	2 /	4	9	-	11	LW-01, LW-01DP

Semi-volatiles
Units in ug/L

Compound Name	Detections	Samples	Range of Detected Concentrations			Detection Locations
bis(2-Chloroethyl)Ether	2 /	4	100	-	120	LW-01, LW-01DP

Alternate Pesticides
Units in ug/L

Compound Name	Detections	Samples	Range of Detected Concentrations			Detection Locations
Hexachlorobutadiene	3 /	4	0.012	-	0.016	LW-01, LW-01DP, LW-03MS

Inorganics
Units in mg/L

Compound Name	Detections	Samples	Range of Detected Concentrations		
Aluminum	4 /	4	1.68	-	9.6
Arsenic	4 /	4	0.007	-	0.0098
Barium	4 /	4	0.0715	-	1.72
Beryllium	1 /	4	0.0015		
Calcium	4 /	4	30.5	-	273
Chromium	2 /	4	0.0057	-	0.0126
Cobalt	3 /	4	0.004	-	0.0125
Iron	4 /	4	2.72	-	129
Lead	1 /	4	0.0672		
Magnesium	4 /	4	24	-	80.1
Manganese	4 /	4	0.0971	-	2.67
Nickel	3 /	4	0.0176	-	0.0343
Potassium	4 /	4	2.21	-	54.9
Selenium	2 /	4	0.0027	-	0.0028
Silver	1 /	4	0.0031		
Sodium	4 /	4	16.4	-	188
Thallium	2 /	4	0.0011	-	0.0019
Vanadium	4 /	4	0.0036	-	0.0154
Zinc	4 /	4	0.142	-	0.397

Table 5.21
SKINNER LANDFILL
Summary of Area Analytical Results
Leachate Sediment Samples

Volatiles
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations		Detection Location
Methylene Chloride	2 /	3	0.015 -	0.041	LS-02, LS-03
2-Butanone	2 /	3	0.003 -	0.11	LS-01, LS-03
Toluene	1 /	3	0.021		LS-01

Semi-volatiles
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations		Detection Location
Phenol	1 /	6	0.056		LS-02RE
Acenapthene	2 /	6	0.049 -	0.071	LS-01, LS-01RE
Dibenzofuran	2 /	6	0.046 -	0.064	LS-01, LS-01RE
Fluorene	2 /	6	0.06 -	0.083	LS-01, LS-01RE
Phenanthrene	4 /	6	0.054 -	0.22	LS-01, LS-01RE, LS-02, LS-02RE
Anthracene	2 /	6	0.05 -	0.05	LS-01, LS-01RE
Fluoranthene	4 /	6	0.094 -	0.4	LS-01, LS-01RE, LS-02, LS-02RE
Pyrene	4 /	6	0.073 -	0.3	LS-01, LS-01RE, LS-02, LS-02RE
Butyl(benzyl)pthalate	2 /	6	0.059	0.091	LS-01, LS-01RE
Benzo(a)Anthracene	4 /	6	0.047 -	0.18	LS-01, LS-01RE, LS-02, LS-02RE
Chrysene	4 /	6	0.054 -	0.2	LS-01, LS-01RE, LS-02, LS-02RE
bis(2-ethylhexyl)Phthalate	1 /	6	0.13		LS-01RE
Benzo(b)Fluoranthene	4 /	6	0.046 -	0.21	LS-01, LS-01RE, LS-02, LS-02RE
Benzo(k)Fluoranthene	4 /	6	0.061 -	0.21	LS-01, LS-01RE, LS-02, LS-02RE
Benzo(a)Pyrene	4 /	6	0.058 -	0.17	LS-01, LS-01RE, LS-02, LS-02RE
Inden(1,2,3-cd)Pyrene	2 /	6	0.072 -	0.1	LS-01, LS-01RE
Benzo(g,h,i)Perylene	2 /	6	0.069 -	0.11	LS-01, LS-01RE, LS-02, LS-02RE

Pesticides
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations		Detection Location
gamma-BHC (Lindane)	1 /	3	0.037		LS-01

Alternate Pesticide Scan
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations		Detection Location
Hexachlorobenzene	1 /	3	1.3		LS-01
Hexachlorobutadiene	2 /	3	1.6 -	47	LS-01, LS-02
1,2,3,4,5,7,7-Heptachloronorborene	3 /	3	1.8 -	3.8	LS-01, LS-02, LS-03

ND - Non Detect

Table 5.21 (continued)
SKINNER LANDFILL
Summary of Area Analytical Results
Leachate Sediment Samples

Inorganics
Units in mg/Kg

Compound Name	Detections	Samples	Range of Detected Concentrations
Aluminum	3 /	3	4270 - 30200
Antimony	2 /	3	7.8 - 9.7
Arsenic	3 /	3	5.8 - 11
Barium	3 /	3	97.8 - 269
Beryllium	3 /	3	0.76 - 1.7
Calcium	3 /	3	33800 - 151000
Chromium	3 /	3	13.5 - 33.3
Cobalt	3 /	3	9.5 - 18.9
Copper	3 /	3	19.6 - 37.2
Iron	3 /	3	16300 - 47100
Lead	3 /	3	13.2 - 78.3
Magnesium	3 /	3	6190 - 35000
Manganese	3 /	3	710 - 2400
Nickel	3 /	3	15.6 - 26.3
Potassium	3 /	3	3340 - 7710
Sodium	3 /	3	291 - 587
Vanadium	3 /	3	28.3 - 60.7
Zinc	3 /	3	40.8 - 180

ND - Non Detect

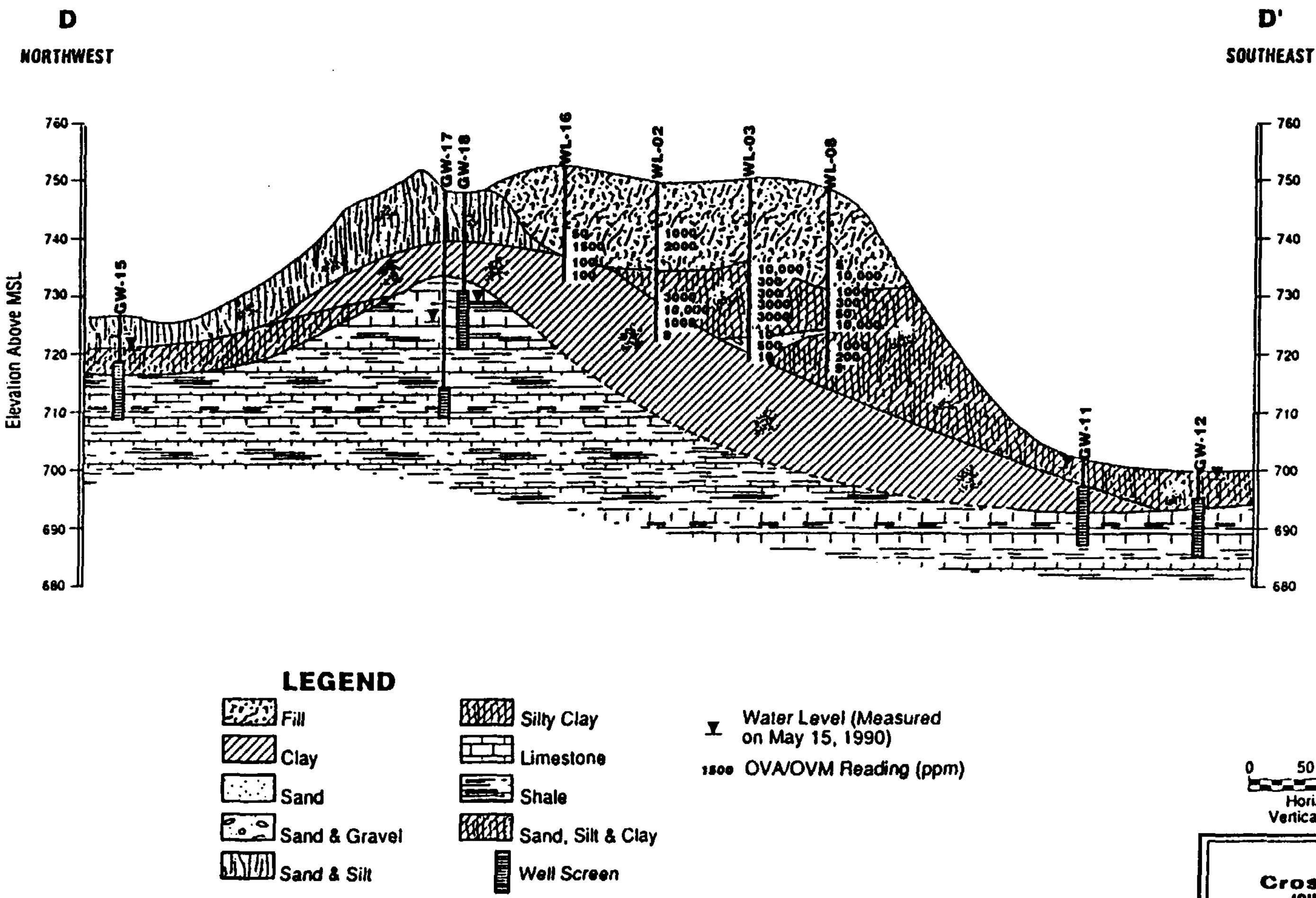


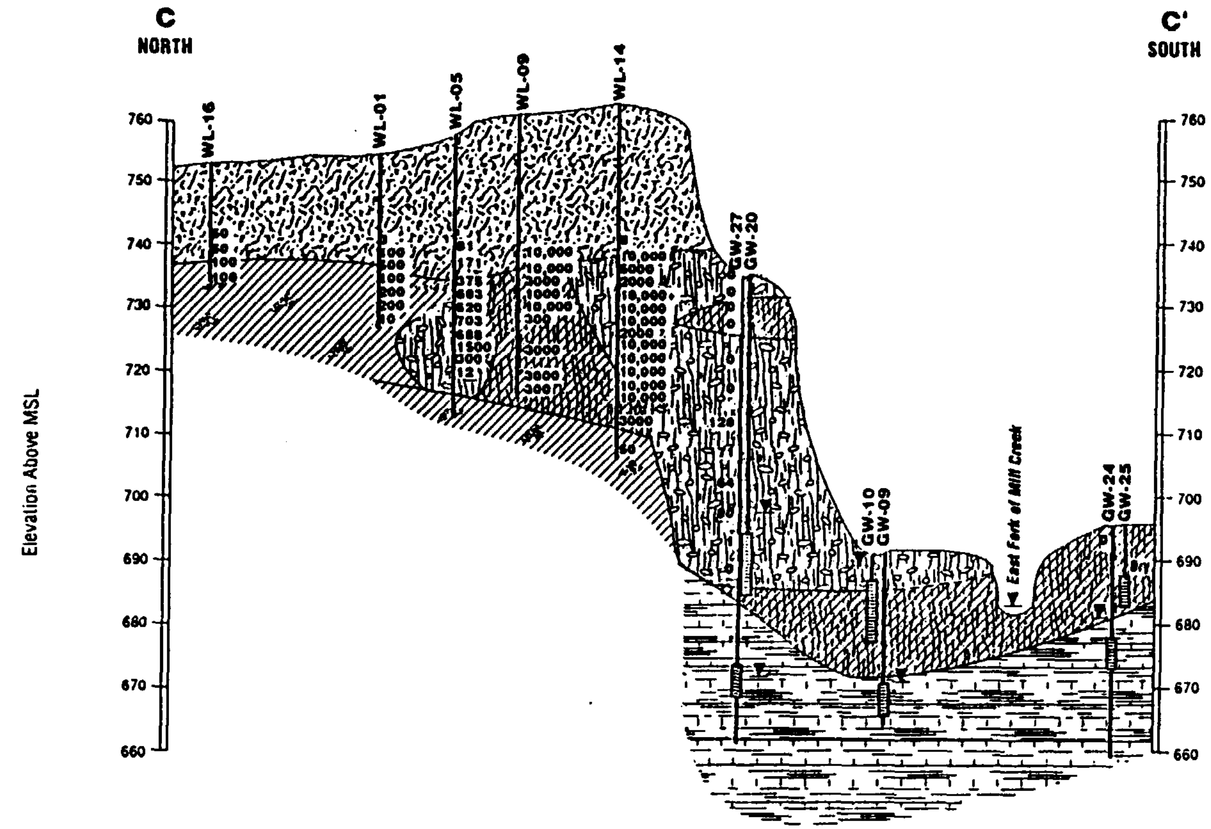
Figure 5.3

Cross Section D-D'
(GW-15 through GW-12)

Skinner Landfill
West Chester, Ohio

February, 1991 04003 14

WW Engineering & Science



LEGEND

- Fill
- Clay
- Sand
- Sand & Gravel
- Sand & Silt
- Silty Clay
- Limestone
- Shale
- Gravel & Sand, Silty
- Well Screen
- Water Level (Measured on May 15, 1990)
- 10,000 OVA/OVM Reading (ppm)

NOTE:
1. Water level in East Fork of Mill Creek is estimated.

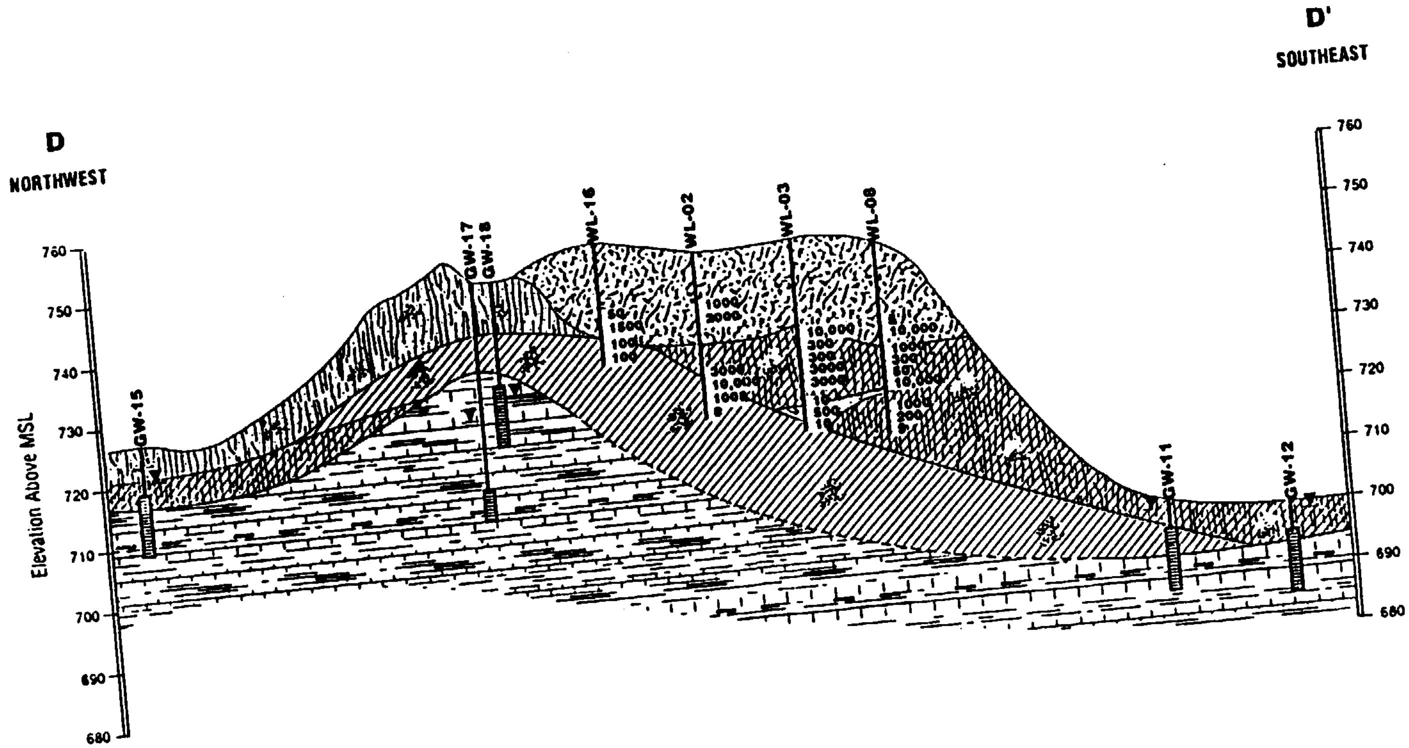
0 50 100 200
Horizontal Scale in Feet
Vertical Scale in Feet: 1"=20'

Figure 5 2

Cross Section C-C'
(WL-16 through GW-25)

Skinner Landfill
West Chester, Ohio

February, 1991 04003 14



LEGEND

- Fill
- Clay
- Sand
- Sand & Gravel
- Sand & Silt
- Silty Clay
- Limestone
- Shale
- Sand, Silt & Clay
- Well Screen
- Water Level (Measured on May 15, 1990)
- 1500 OVA/OVM Reading (ppm)

0 50 100 200
Horizontal Scale in Feet
Vertical Scale in Feet: 1"=20'

Figure 5.3

Cross Section D-D'
(GW-15 through GW-12)

Skinner Landfill
West Chester, Ohio

February, 1991 04003 14

WW Engineering & Science

...s (ppm)

- Sand & Gravel
- Sand & Silt
- Gravel & Sand, Silty
- Well Screen

NOTE:
1. Water level in East Fork of Mill Creek is estimated.

0 50 100 200
Horizontal Scale in Feet
Vertical Scale in Feet: 1"=20'

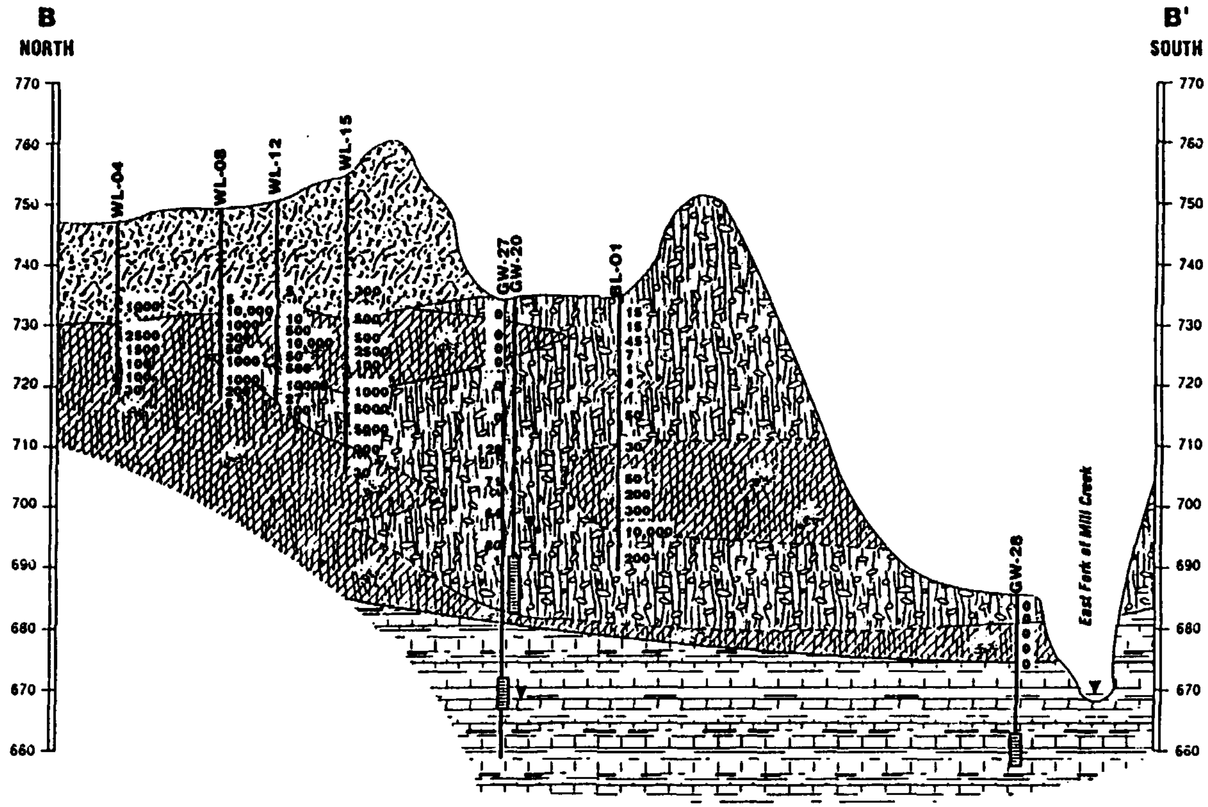
Figure 5.2

Cross Section C-C'
(WL-16 through GW-25)

Skinner Landfill
West Chester, Ohio

February, 1991 04003 14

WW Engineering & Science



LEGEND

- Fill
- Sand
- Gravel
- Sand & Gravel
- Clay, Sand & Gravel
- Sand & Silt
- Sand & Gravel, Silty
- Clay & Silt
- Limestone
- Shale
- Well Screen
- Water Level (Measured on May 15, 1990)
- 128 OVA/OVM Reading (ppm)

NOTE:
1. Water level in East Fork *of Mill Creek is estimated.*

0 50 100 200
Horizontal Scale in Feet
Vertical Scale in Feet: 1"=20'

Figure 5.1

Cross Section B-B'
(WL-04 through GW-28)

Skinner Landfill
West Chester, Ohio

February, 1991 04003.14

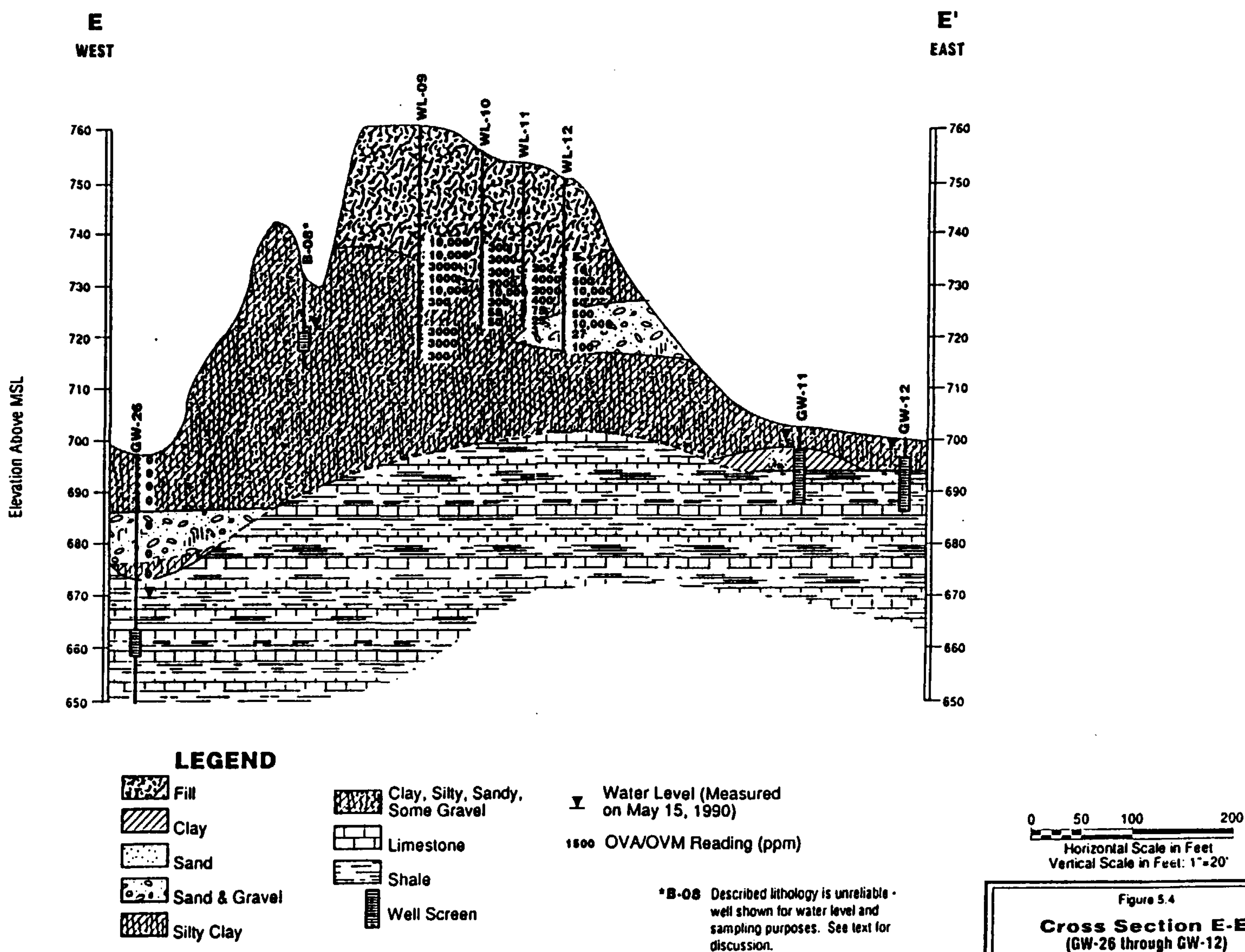
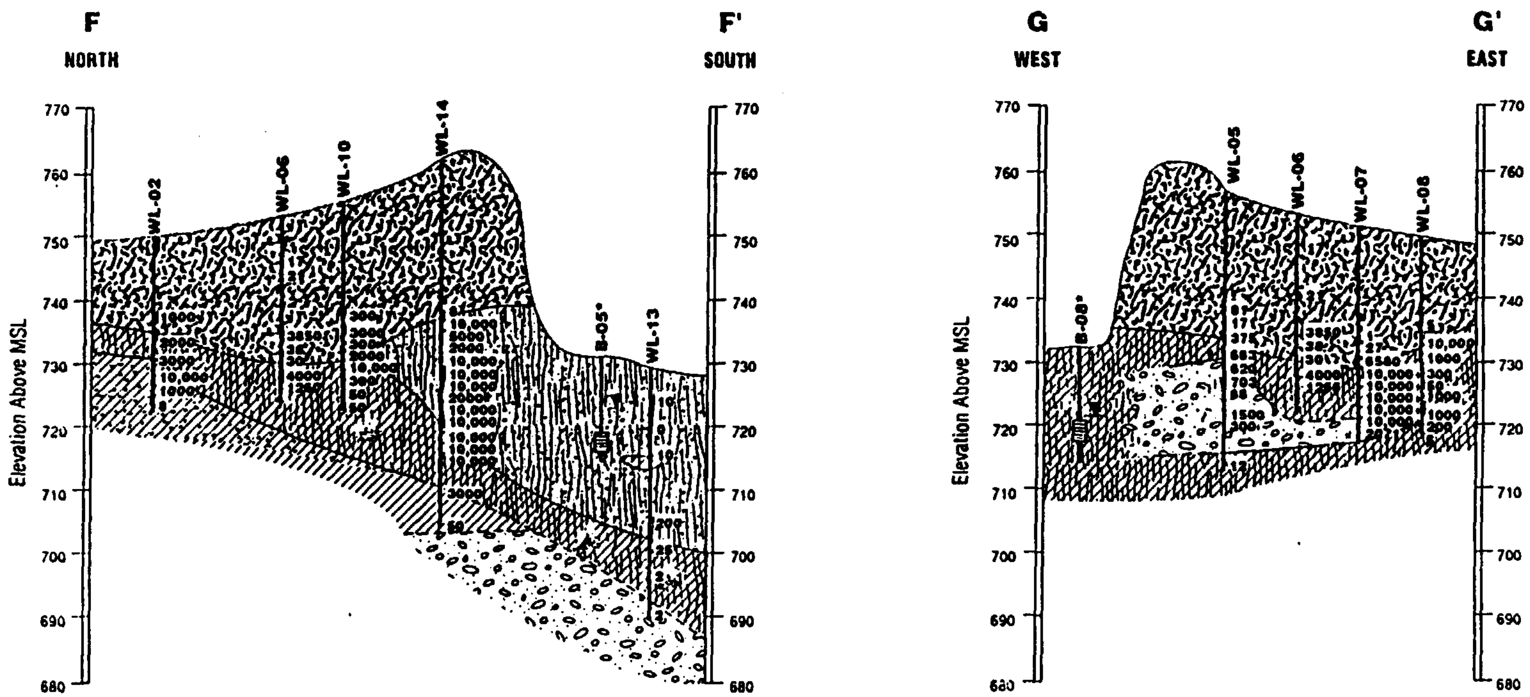


Figure 5.4

Cross Section E-E'
(GW-26 through GW-12)

Skinner Landfill
West Chester, Ohio

February, 1991 04003 14



LEGEND

Fill
Clay
Sand & Gravel
Sand & Silt
Sand & Gravel, Silty
Silty Clay
Limestone
Shale
Bedrock
Well Screen

Water Level (Measured on May 15, 1990)

1500 OVA/OVM Reading (ppm)

*B-05 Described lithology is unreliable - well shown for water level and sampling purposes. See text for discussion.

*B-08 Described lithology is unreliable - well shown for water level and sampling purposes. See text for discussion.

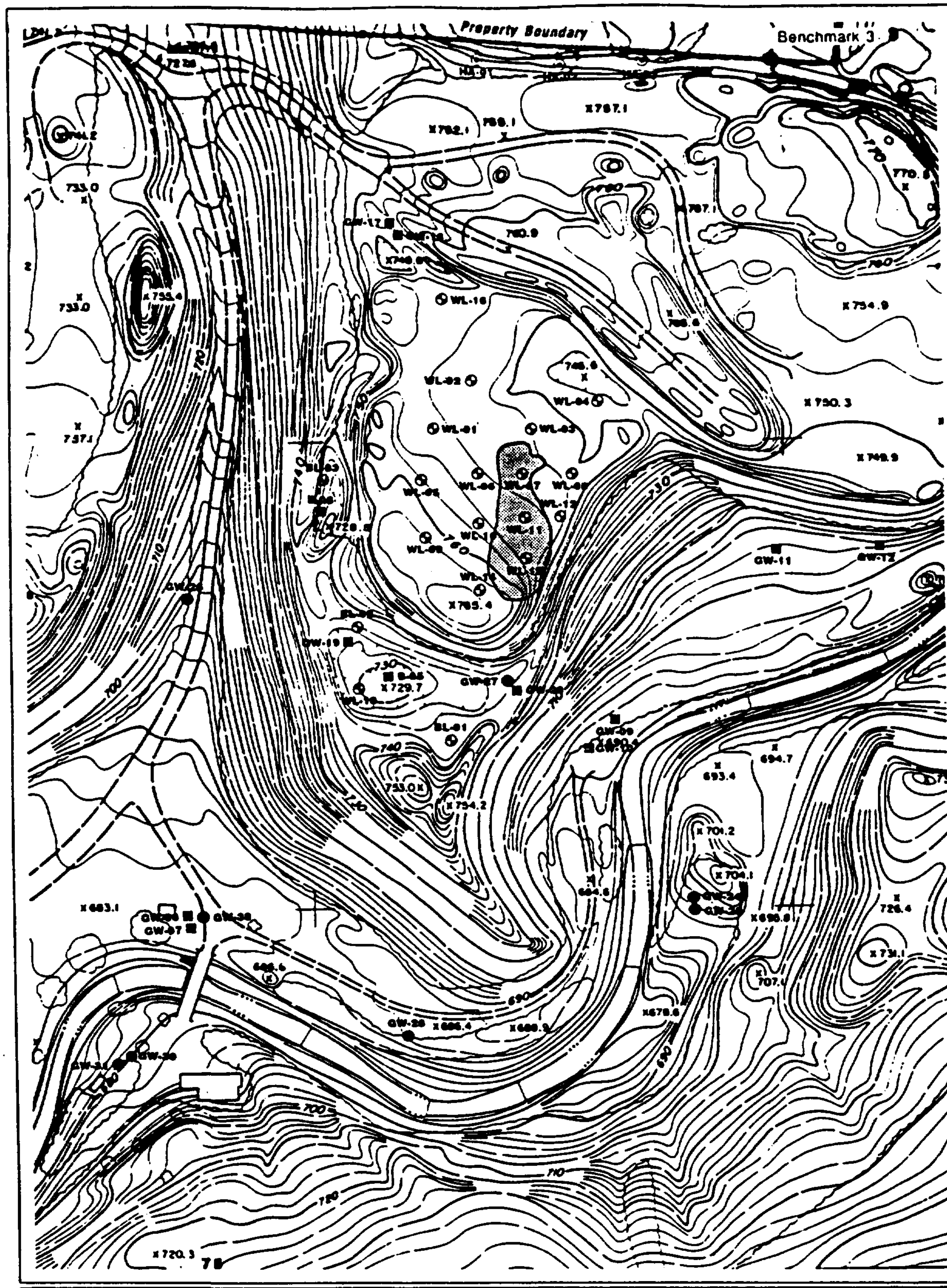
0 50 100 200
Horizontal Scale in Feet
Vertical Scale in Feet. 1"=20'

Figure 5.5

Cross Section F-F' and G-G'
(WL-02 through WL-13 and B-08 through WL-08)

Skinner Landfill
West Chester, Ohio

February, 1991 04003 14



LEGEND

- Pre Phase II Wells
- Hand Auger
- Soil Boring/Monitor Well
- Soil Boring

Approximate Area of Lagoon from Aerial Photos

0 50 100 200

Scale in Feet

Figure 2.4, 5.6

WASTE LAGOON AREA

Monitor Well and Soil Boring Location Map

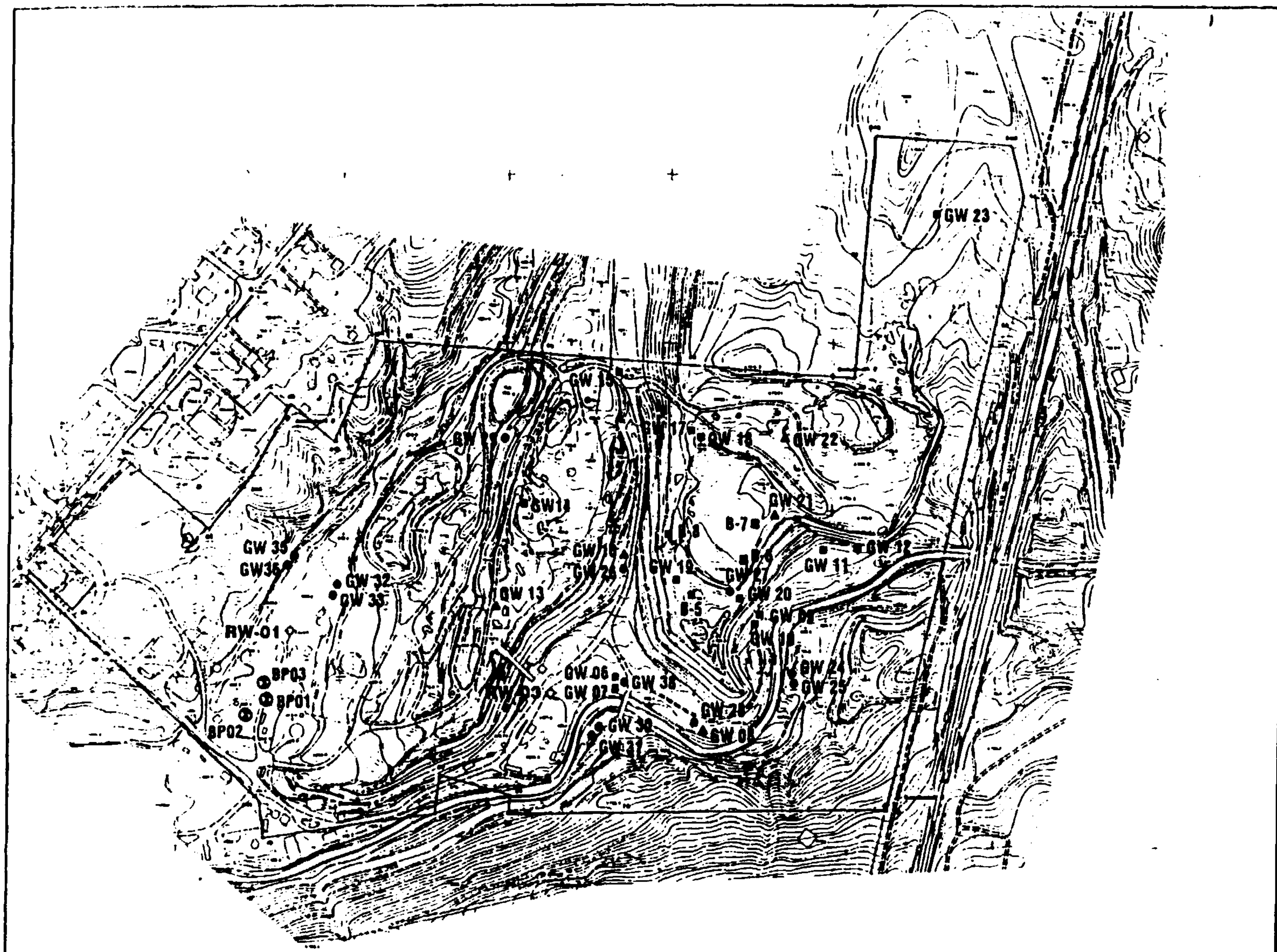
Skinner Landfill

West Chester, Ohio

November, 1990

04003.14

WW Engineering & Science



LEGEND

- ● Monitoring Well (Phase II)
- ■ Monitoring Well (pre-Phase II)
- ▲ Abandoned Monitoring Well
- ⊕ Buried Pit Boring
- ◇ Residential Well

Note: Former Locations of B-6 and B-7 are approximate

N

0 150 300 600

Scale in Feet

Figure 2.3, 5.7

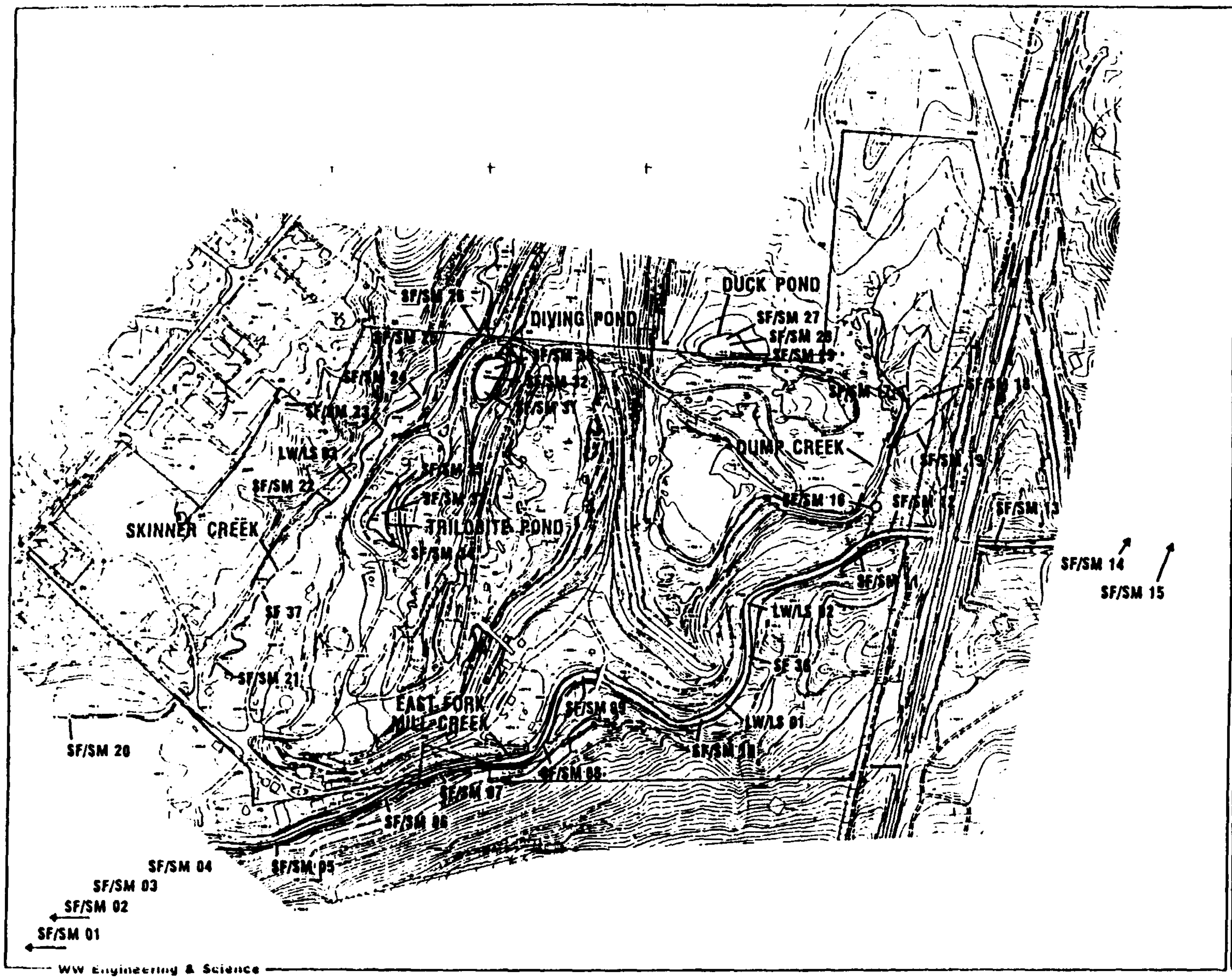
Site Map with Monitoring Well, Residential Well and Buried Pit Boring Locations

Skinner Landfill

West Chester, Ohio

February, 1991 04003.14

WW Engineering & Science



WW Engineering & Science

LEGEND

SF 37 Surface Water Sample

SF/SM 01 Surface Water and Sediment Sample

LW/LS 01 Leachate Water and Sediment Sample

Disappearance Point of Stream

Spring/Appearance Point of Stream

N

0 150 300 600

Scale in Feet

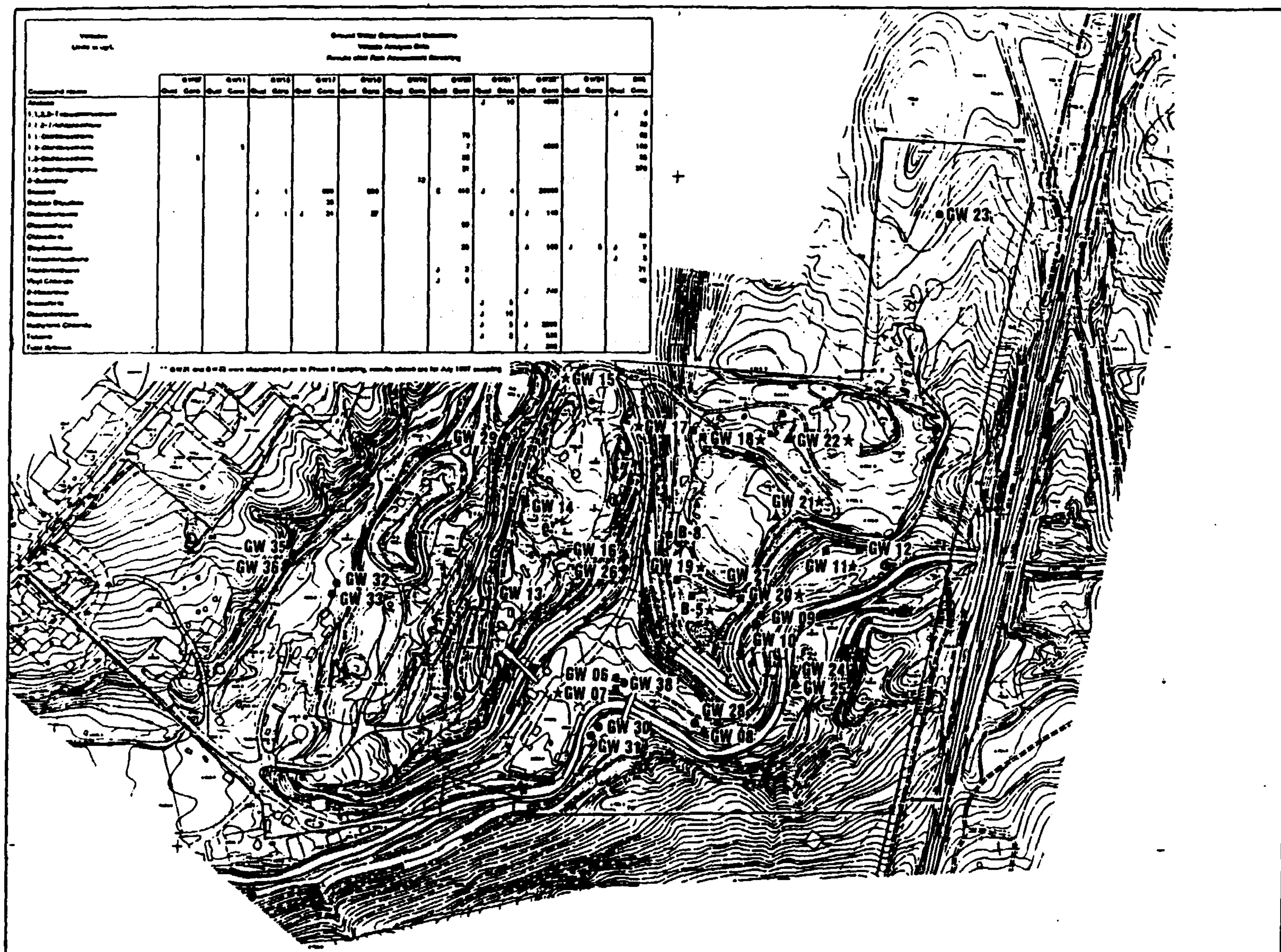
Figure 2.2,5.8

SURFACE WATER, SEDIMENT AND LEACHATE SAMPLING LOCATIONS

Skinner Landfill
West Chester, Ohio

February, 1991

04003 1



LEGEND

- ● Monitoring Well (Phase II)
- ■ Monitoring Well (pre-Phase II)
- ▲ Abandoned Monitoring Well
- ★ Volatile Organic Compounds Detected

N

0 150 300 600

Scale in Feet

Figure 5.9

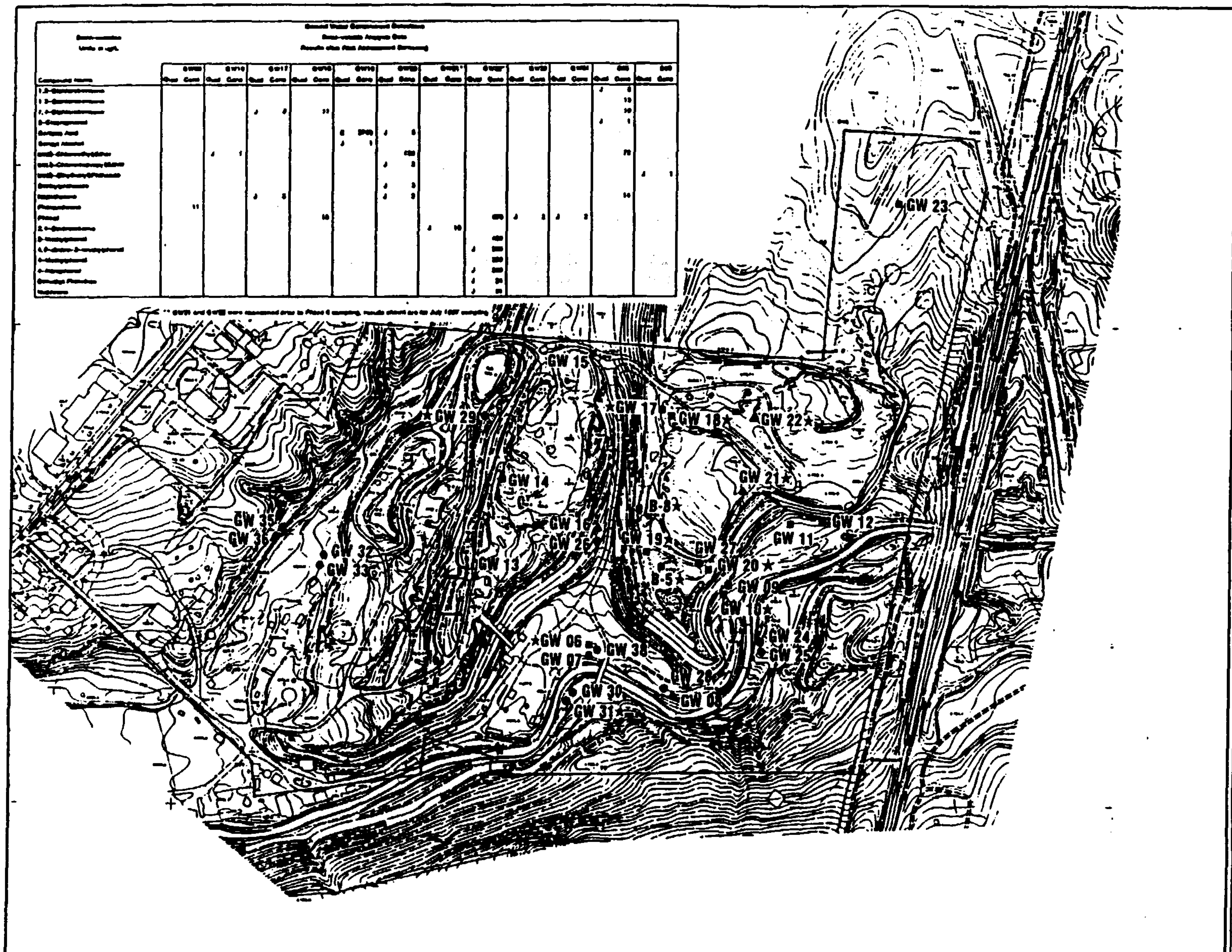
AREAL DISTRIBUTION OF GROUND WATER VOLATILE ORGANIC COMPOUNDS

Skinner Landfill

West Chester, Ohio

February, 1991 04003.14

WW Engineering & Science



LEGEND

- ● Monitoring Well (Phase II)
- ■ Monitoring Well (pre-Phase II)
- ▲ Abandoned Monitoring Well
- ★ Semi-Volatile Organic Compounds Detected

0 150 300 600

Scale in Feet

Figure 5.10

AREAL DISTRIBUTION OF GROUND WATER SEMI-VOLATILE ORGANIC COMPOUNDS

Skinner Landfill

West Chester, Ohio

February, 1991 04003.14

6.0 SUMMARY AND CONCLUSIONS

The field investigation portion of the Phase II Skinner site remedial investigation has been completed. The scope of work accomplished included:

- Geologic investigation and evaluation.
- Hydrogeologic investigation and evaluation.
- Ground water sampling and analysis.
- Surface water and sediment sampling and analysis.
- Soil sampling and analysis.
- Definition, sampling and characterization of the buried waste lagoon.
- Definition, sampling and characterization of the buried pit.

The following are brief summaries of the results of the Phase II investigation.

6.1 GEOLOGY

The geologic conditions present beneath the Skinner site, as revealed by the Phase I and Phase II borings, are consistent with the regional geologic setting. Bedrock consists of thinly bedded Ordovician carbonates and shales which may form steep walled bedrock valleys . The bedrock surface topography is dominated by two high areas, one beneath the metal storage area and the second. beneath and to the north of the buried waste lagoon. Visual inspection of the carbonate bedrock exposed along the East Fork of Mill Creek and at Trilobite Pond reveals a prominent fracture system oriented approximately north-south with a secondary, less pronounced, less continuous fracture system occurring at approximately a 90 degree angle to the first. Fracture spacing varies between four and fourteen inches in both fracture sets.

The glacial history in the Cincinnati area is represented by the unconsolidated sediment deposits which grade from clay to gravel, reflecting the cyclical depositional settings associated with an advancing and retreating ice sheet. Correlation of the unconsolidated sediments is more obvious along the valley axes and the depositional strike. Unconsolidated sediment thickness is as great as 60 feet. Bedrock valleys are slowly being reexcavated by the post-glacial streams. These streams are also modifying the bedrock surface where carbonate and shale are exposed in the East Fork of Mill Creek valley.

6.2 HYDROGEOLOGY

The infiltration of precipitation into the glacial sediments provides the majority of ground water recharge at the Skinner site. Infiltrating precipitation produces locally perched ground water conditions. This condition was encountered above less permeable sediments during the waste lagoon investigation. The infiltration of water through the debris and buried waste lagoon likely produces the leachate observed discharging to the East Fork of Mill Creek.

Ground water flow within the glacial sediments occurs preferentially along the higher permeability deposits of sand and gravel and along the buried bedrock valleys. The flow within the unsaturated zone likely follows the upper surfaces of the less permeable zones and may be unrelated to the water table within the unconsolidated sediments.

Two ground water flow divides are apparent from the contoured water levels. The first corresponds with the metal storage area while the second corresponds with the buried lagoon. Ground water flow in the buried waste lagoon area is radial toward the bedrock valleys and the East Fork of Mill Creek. Ground water flow velocities were calculated for two flow vectors emanating from the buried waste lagoon. These two flow vectors intersect different sediment types with corresponding variations in permeabilities. The calculated velocity to the south east, toward the East Fork of Mill Creek, is 3.38 ft/day while the calculated velocity to the south west, toward GW06, is 0.069 ft/day. The ground water flow velocities may be overestimated due to the steep apparent hydraulic gradient (approximately 0.1). It is likely that ground water flow is interrupted by the heterogeneous textures of the unconsolidated sediments.

Bedrock is largely interpreted to be an insignificant pathway for contaminant migration. The ground water flow within the bedrock occurs predominantly along the bedding planes and fractures. The clay tills which commonly overlie the bedrock combine with the limited vertical permeability in the bedrock to inhibit ground water flow between the unconsolidated units and the bedrock. Downward vertical gradients occur across the bedrock contact), indicating that the potential exists for recharge, but the low vertical permeabilities along the contact limit the significance of this flow path. Ground water likely follows the upper surface of the bedrock and clayey formations. Further evidence for these conclusions is found in the evaluation of the water chemistry, as presented in the stiff diagrams.

6.3 CONTAMINANT SOURCES

The buried waste lagoon is both the largest and the most significant source of contamination at the Skinner site. Additional contamination may be sourced in the contents of drums sampled in 1976 and 1986, located to the north of the buried waste lagoon.

6.3.1 BURIED WASTE LAGOON

Of the 19 soil borings completed in or around the buried waste lagoon, 15 encountered fill material, with a maximum thickness of 26 feet being recorded at WL-10 and an average fill thickness of 20.1 feet. The estimated area of the debris overlying the impacted soils is 8.8×10^4 ft^2 with an estimated volume of 1.6×10^6 ft^3. Typical debris descriptions include wood, plastic, metal, brick, wire, glass, paper and rubber.

A contour map of estimated natural soil elevations revealed an apparent depression below the debris which may correspond to the former lagoon. Several borings encountered tar-like material, oily sediments and sticky liquids described as raspberry and turquoise in color. These materials were found above the natural soils and below the debris and are interpreted to be related to the former lagoon. The physical base of the lagoon is located entirely above the unconsolidated water table. Some interaction with perched ground water or infiltrating surface water in the unsaturated zone may, however, be occurring.

Field screening of split spoon samples taken within and below the buried lagoon revealed high concentrations of volatile organic compounds. These readings, when plotted on cross sections bisecting the lagoon and debris, and extend into the natural soils. Less permeable sediments appear to resist the downward migration of contaminants. Infiltrating water may follow similar migration pathways when interacting with the water table and when generating leachate. The volume of impacted soils, based upon the volatile organic compounds detected during the field screening, is estimated at 2.9×10^6 ft^3.

6.3.2 BURIED PIT

Three borings were drilled in or around the buried pit. The material interpreted as fill included pieces of wood which would not be expected in naturally occurring sediments. The fill material is not readily differentiated from the naturally occurring sediments, although some black discoloration was observed in one sample. Saturated soils were encountered at less than one foot of depth, rendering field screening for volatile organic compounds useless. The extent of the fill material shown on the cross section is estimated.

6.4 ANALYTICAL RESULTS

The results of the analytical sampling undertaken during the Phase II investigation confirmed the buried lagoon as the primary source of contaminants at the Skinner site.

6.4.1 SOILS

The analytical results of the Phase II soil sampling indicate four principal areas of concern: the buried waste lagoon and adjacent area; the buried pit; the area surrounding GW-29, located downslope to the west of the metal storage area; and the GW-38 area located near the East Fork of Mill Creek.

Compounds detected in the buried waste lagoon soil samples correlate with elevated organic vapor field readings and with soil stainings. Chemicals of concern include volatile organic compounds, semi-volatile organic compounds, pesticides, metals and low levels of PCB's, dioxins and furans. The pesticides encountered are largely immobile, bind tightly to the clayey soils and have a low solubility in water. The permeability of the soils beneath the buried waste lagoon appear to affect compound distribution and movement, as revealed by the field screening. The ground water and leachate contamination in the buried waste lagoon area results from the infiltration of surface water through these highly contaminated soils.

Analysis of the buried pit area soil samples reveals generally lower compound concentration levels and a lesser number of compounds than seen at the buried waste lagoon area. Soil samples contained volatile organic compounds, semi-volatile organic compound, pesticides and metals.

Soil samples from GW-29 contained low levels of volatile and semi-volatile organic compounds, furans and several metals. The number of compounds present are few and may be sourced from the metal storage area or originate in an isolated or localized spill.

Soil samples from GW-38 contained volatile and semi-volatile organic compounds, dioxins and furans. These compound may originate within the waste lagoon or from within the piles of scrap metal and debris found adjacent to the well.

6.4.2 GROUND WATER

The majority of ground water contamination in the unconsolidated sediments appears to originate from within the buried waste lagoon. Additional sources may exist to the north of the buried lagoon within the drums sampled in 1976 and 1986. Contaminants emanating from the buried lagoon may be migrating preferentially through the more permeable sediments on the southeastern side of the lagoon, based upon both the contaminant distribution and the previously described ground water velocities.

Two wells, GW-20 and B-05, located immediately adjacent to and downgradient from the lagoon, are the most severely impacted. These wells contain a wide variety of contaminants with the majority being volatile organic and chlorinated semi-volatile organic compounds.

Contamination of GW-15, GW-17 and GW-18, located to the north of the main lagoon area, may reflect alternate pollutant sources. Historically, the area to the north of the lagoon and active fill areas contained drums which, when sampled in 1976, contained benzene, ethyl benzene and toluene. WESTON's surface geophysical surveys appeared to define several possible buried drum nests in the area to the northwest of the buried lagoon, indicating that there may be several point sources of contaminants in addition to the buried waste lagoon. The detections in GW-17 and GW-18 represent the majority of bedrock ground water contamination. These wells are screened within a bedrock high which protrudes into and above the unconsolidated sediment water table. WESTON described the screened lithology as a "pebbly-shale" and permeabilities in these two wells are greater than other bedrock wells.

The ground water contamination present in the bedrock well GW-09 appears to originate in the waste lagoon. The contaminants detected are principally dense chlorinated compounds which were known to be disposed of in the waste lagoon but are also associated with the breakdown of the waste lagoon pesticides. This well is screened just below the bedrock contact on the floor of the buried valley to the southeast of the lagoon.

6.4.3 Surface Water, Sediment, and Leachate

The leachate seeps entering the East Fork of Mill Creek contained volatile organics, semi-volatile organics and pesticide compounds in the leachate water and sediment. The only significant organic compound detected in the leachate water from the Skinner Creek seep (LW-03) was the pesticide hexachlorobutadiene. This pesticide compound was also detected in a water sample from Trilobite Pond which suggests that the pond and the seep are in hydraulic communication. This suggestion is supported by pH and specific conductivity values. Petroleum odors, however, seem to link this seep to Diving Pond.

The set of compounds detected in LW-01 were also found in the ground water sample obtained from GW-20, located upgradient of the leachate seep and below the waste lagoon. This pattern suggests that the seep is a direct discharge point for ground water originating in, and impacted by, the waste lagoon. Discharge at LW-01 may be induced or aided by the drainage pipe while discharge at LW-02 appears to be controlled by lithology, as discussed in Section 4.4.4, and supported by the soil vapor screening, specific conductivity and pH measurements. The leachate sample LW-01 did not contain any of the contaminants seen in LW-02 but the corresponding sediment sample, LS-01, contained many of the same compounds as LS-02. The majority of detections in the sediments were semi-volatile compounds.

The laboratory analyses of surface water and sediment samples form the Skinner site showed the presence of volatile organic compounds, semi-volatile organic compounds, pesticides, PCB's and metals at low concentrations.

No significant surface water contamination of East Fork of Mill Creek was observed. A variety of semi-volatile organic compounds, pesticides and PCB's were detected in sediment samples from the creek, however. Similar observations were made of Skinner Creek as no significant surface water contamination was observed, but volatile organic, semi-volatile organic and pesticide compounds were detected in Skinner Creek sediment samples in the vicinity of SM-20 and SM-21, near the buried pit and the main site access road.

Water samples from Duck Pond and Dump Creek did not reveal significant amounts of contamination. The sediments of Duck Pond were shown to be impacted by pesticides while Dump Creek sediments contained detectable levels of volatile organics, semi-volatile organics and a single low level detection of a pesticide compound.

Water samples from Trilobite and Diving Ponds both contained low concentrations of pesticides. Semi-volatile organics were detected in water collected near the base of Trilobite Pond. Sediments from Diving Pond contained detectable levels of volatile organics, semi-volatile organics, PCB's and pesticides. The sediment samples from Trilobite Pond were relatively unimpacted, but have been recently disturbed and altered through dredging and excavating activities by the landfill operator.

The draft risk assessment submitted in December 1990 compared the results of the on-site surface water and sediment sampling on the Skinner site to background sample locations. This process of comparison will determine if the contamination encountered is attributable to the historic disposal process or attributable to off-site sources. The risk assessment will evaluate which, if any, of the compounds pose a threat to human health or the environment.

6.5 POTENTIAL OFF-SITE MIGRATION

The results of the Phase II Remedial Investigation indicate that there is limited potential for significant off-site migration of contaminants from the Skinner site. The only evidence of contaminants potentially leaving the site through ground water migration was a detection of ethylbenzene at 5 ug/l from the bedrock well GW-24 located across the East Fork of Mill Creek from the buried waste lagoon. This low concentration and the fact that only a single organic parameter was detected may indicate that the ethylbenzene detection was invalid.

The only other potential off-site migration route is through the East Fork of Mill Creek and Skinner Creek. The leachate seeps discharging into the East Fork of Mill Creek appear to originate within the buried waste lagoon. A variety of contaminants were detected in surface waters and sediments from the creeks at low concentrations. The Risk Assessment will evaluate the potential effects of the surface water and sediment contamination on human health and the aquatic environment.

7.0 REFERENCES

Bernhagen, Ralph J. and Edward J. Schaefer (1947) Ground Water Conditions in Butler and Hamilton Counties, Ohio, 1946, Bulletin 8, Ohio Water Resources Board, Columbus, Ohio, .

Bouwer, H., 1989. The Bouwer and Rice Slug Test - an update: Ground Water, Vol. 27, No. 3, pp. 304-309.

Bouwer, H. and R.C. Rice, 1976. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells: Water Resources Research, Vol. 12, pp. 423-428.

Brahana, J.V., Thrailkill, J., Freeman, T., and Ward, W.C., (1988) Carbonate Rocks, in Back, W., Rosenshein, J.S., and Seaber, P.R., eds., Hydrogeology: Boulder Colorado, Geological Society of America, The Geology of North America, v. O-2.

Davis, S.N., 1969. Porosity and Permeability of Natural Materials: Flow-Through Porous Media. New York: Academic Press, pp. 54-89.

Davis, Stanley N. (1988) Sandstones and Shales, in Back, W., Rosenshein, J.S., and Seaber, P.R., eds., Hydrogeology: Boulder, Colorado, Geological Society of America, The Geology of North America, v. O-2.

Dennis, S.T., (1987). The Effect of Well Efficiency on *In Situ* Permeability Test Results. Master's Thesis, Western Michigan University, p. 56.

Drever, James I (1988) The Geochemistry of Natural Waters, 2nd Edition. Prentice Hall, Inc. New Jersey.

Driscoll, F.G., 1986. Ground Water and Wells. St. Paul, MN: Johnson Filtration Systems, Inc. p 1089.

Freeze, R.A. and J.A. Cherry, 1979. Ground Water. Englewood Cliffs, NJ: Prentice-Hall, Inc. p 604.

Hem, John D (1985) Study and Interpretation of the Chemical Characteristics of Natural Water, 3rd Edition, US Geological Survey Water-Supply Paper 2254, United States Government Printing Office, Virginia.

Hosler, J.L. (1976) Report of Geology and Ground Water Resources, West Chester, Butler County, Ohio.

Keys, W.S. (1989) Borehole Geophysics Applied to Ground-Water Investigations, National Water Well Association, Dublin, Ohio, 1989.

Klaer, Fred H. and David G. Thompson (1948) "Ground Water Resources of the Cincinnati Area, Butler and Hamilton Counties", Water Supply Paper 999, USGS, Washington.

Krothe, N.C., and Kempton, J.P. (1988) Central Glaciated Plains, in Back, W., Rosenshein, J.S., and Seaber, P.R., eds., Hydrogeology: Boulder, Colorado, Geological Society of America, The Geology of North America, v. O-2.

Seaber, P.R., Brahana, J.V., and Hollyday, E.F. (1988) Region 20, Appalachian Plateaus and Valley and Ridge, in Back, W., Rosenshein, J.S., and Seaber, P.R., eds., Hydrogeology: Boulder, Colorado, Geological Society of America, The Geology of North America, v. O-2.

Speiker, Andrew M. (1961) "A Guide to the Hydrogeology of the Mill Creek and Miami River Valleys, Ohio" in Guidebook for Field Trips, Cincinnati Meeting, GSA, New York, New York.

Stephenson, D.A., Fleming, A.H., and Mickelson, D.M. (1988) Glacial Deposits, in Back, W.,Rosenshein, J.S., and Seaber, P.R., eds., Hydrogeology: Boulder, Colorado, Geological Society of America, The Geology of North America, v. O-2.

Struble, Richard A. (1986) Sand and Gravel Resources of Butler County, Ohio, Report of Investigations No. 130, Division of Geological Survey, State of Ohio.

Thelen, G.J., November 5, (1980) Subsurface Survey, Section 13: Dalewood Subdivision. Upper Mill Creek Regional Wastewater Facility, Butler County, Ohio.

Weiss, M.D., W.R. Edwards, C.E. Norman, and E.R. Sharp. 1965. The American Upper Ordovician Standard VII Stratigraphy and Petrology of the Cynthiana and Eden Formations of the Ohio Valley, Geological Society of America Special Paper 81, 76pp.